3

REPORT RESUMES

ED 002 829 24
VERBAL LEARNING AMONG CHILDREN WITH REDUCED HEARING ACUITY.
BY- GAETH, JOHN H. AND OTHERS
WAYNE STATE UNIV., DETROIT, MICH.
REPORT NUMBER CRP-289 PUB DATE 60
EDRS PRICE MF-$0.18 HC-$5.00 125P.

DESCRIPTORS- *VERBAL LEARNING, *AURALLY HANDICAPPED, LEARNING PROCESSES, *AUDIOVISUAL INSTRUCTION, TEACHING TECHNIQUES, SENSORY EXPERIENCES, *MULTISENSORY LEARNING, CLASSROOM COMMUNICATION, SPEECH IMPROVEMENT, ACADEMIC ACHIEVEMENT, *STIMULUS DEVICES, VERBAL ABILITY, AGE GROUPS, COMPARATIVE ANALYSIS, DETROIT, MICHIGAN

COMBINED VISUAL-AUDITORY METHODS FOR TEACHING WERE TESTED, USING AURALLY HANDICAPPED AND NORMAL CHILDREN AS SUBJECTS, TO DEVELOP COMPARATIVE STATISTICS OF LEARNING ABILITY AND AUDITORY TRAINING BENEFITS OVER CONVENTIONAL UNISENSORY TEACHING TECHNIQUES. THE STUDY SAMPLE CONSISTED OF 2,500 CHILDREN. IN THE EXPERIMENTAL PROCEDURE, THE CHILDREN WERE ASKED TO MEMORIZE LISTS OF SIMPLE WORDS PRESENTED VISUALLY (BY MEANS OF A MEMORY DRUM), AUDITORILY (BY THE USE OF A TAPE RECORDER), AND THEN IN A SIMULTANEOUS VISUAL-AUDITORY PRESENTATION. THE BASIC LEARNING FUNCTION WAS DESCRIBED IN NORMAL CHILDREN FROM THE SECOND TO TENTH GRADES AND IN AURALLY HANDICAPPED CHILDREN FROM THE SAME GRADE RANGE WHO HAD SUFFICIENT RESIDUAL HEARING TO RESPOND TO AMPLIFIED STIMULATION. THE SUBJECTS WERE TESTED INDIVIDUALLY, EXCEPT IN ONE GROUP EXPERIMENT. ALTHOUGH NO DEFINITE CONCLUSIONS WERE REACHED REGARDING OVERALL BENEFITS OF THE MULTISENSORY LEARNING TECHNIQUES EMPLOYED, THE PROJECT REPRESENTED AN INITIAL ATTACK UPON THE PROBLEM OF UNDERSTANDING HOW CHILDREN CAN USE AUDITION AND VISION IN LEARNING VERBAL MATERIAL AND HOW HEARING LOSS AFFECTS THIS PROCESS. (JH)

ED 002829

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

VERBAL LEARNING AMONG CHILDREN WITH REDUCED HEARING ACUITY

Submitted to

The Office of Education
Department of Health, Education, and Welfare

As a Final Report
of
Project # 289

John H. Gaeth, Ph. D.
Project Director

Wayne State University Hearing Clinic
Detroit 2, Michigan
1960

ACKNOWLEDGEMENTS

The project was the work of a group of people, and the Project Director takes this opportunity to give credit to the individuals most directly connected with it.

The regularly employed members of the staff were as follows:

First year--Patricia H. Carpenter, Mary M. Collins, and Estelle K. Benjamin.

Second year--Mary M. Collins, Gladys H. Crawford, Sally Fox, and Wilton Murphy.

Third year--Rollie Houchins, Janet LeClair, Clessen Martin, Richard Maxey, Wilton Murphy, and Richard Taylor.

All members of the staff except Benjamin and Crawford were also pursuing graduate study in audiology, psychology, or special education. Miss Collins conducted the doctoral study referred to in the section on Training Projects; LeClair and Houchins carried out the special auditory-training projects.

Credit is due to Millard M. Meador for assistance with the apparatus and to William Wilson for recording the auditory versions of the test material.

The study would not have been possible without the cooperation of the school systems in the Detroit Area. Superintendent S. M. Brownell and his administrative staff of the Detroit Public Schools formally granted the permission to work in the school system. Dr. Walter Bergman, former Director, and Dr. Robert Lankton, Director of the Department of Instructional Research, were helpful in selecting and scheduling schools for testing. Special cooperation was given by Mrs. Ella M. Carroll and Mrs. Harriet G. Kopp, Principals of the Day Schools for the Deaf, and by Miss Hildred A. Gross, Supervisor of Speech Correction and Hearing Conservation.

Credit is also due to the Administrators in the school systems in Ferndale, Plesant Ridge, and Royal Oak, Michigan, and to Dr. John A. Klein of the Lutheran School for the Deaf, for their willingness to cooperate in the testing and training studies.

TABLE OF CONTENTS

Page

LIST OF TABLES iv

LIST OF FIGURES vi

INTRODUCTION 1

OBJECTIVES 3

RELATED RESEARCH 4

APPARATUS, MATERIALS, SUBJECTS, AND PROCEDURE 9

RESULTS OF THE EXPERIMENTS IN VERBAL LEARNING 14

TRAINING PROJECTS 86

SUMMARY AND CONCLUSIONS 96

REFERENCES 106

APPENDIX A 108

APPENDIX B 112

APPENDIX C 115

LIST OF TABLES

Table | Page
1.1 Mean trials to learn the lists under Condition A 16
1.2 Mean trials to learn the lists under Condition V 18
1.3 Mean trials to learn the lists under Condition C 18
1.4 Summary of analysis of variance of four-pair scores under Condition C 20
1.5 Summary of analysis of variance of eight-pair scores under Condition C 22
1.6 Mean trials to learn the lists for the three reference sub-conditions 22
1.7 Mean trials to learn the four-pair lists according to method of presentation 24
1.8 Summary of analysis of variance of pooled four-pair list scores .. 24
1.9 Retention scores for the nine sub-conditions in Experiment I 26
1.10 Summary of analysis of retention scores according to various sub-conditions 27
2.1 Mean trials to criterion for high and low centile groups in five sub-conditions 31
2.2 Summary of analysis of variance for the two centile groups and five sub-conditions 32
2.3 Summary of analysis of variance for the five sub-conditions in the low centile group 33
2.4 Mean retention scores for the five sub-conditions and the two centile groups 33
2.5 Summary of analysis of retention scores for high and low centile groups 34
3.1 Mean trials to learn the eight word-pair list under Condition A .. 37
3.2 Summary of analysis of sub-conditions (A - A and V - A for five grade levels 38

3.3 Mean trials to learn the eight word-pair list under Condition V .. 38

3.4 Summary of analysis of sub-conditions (V - V and A - V) for five grade levels 40

3.5 Mean trials to learn the eight word-pair list for the reference sub-conditions in five grades 42

3.6 Summary of analysis of scores from Reference Sub-conditions A - A, V - V, and C - C for five grade levels 42

3.7 Mean correct responses on retention test for three reference sub-conditions and five grade levels 43

4.1 Mean trials to criterion for the first, second, and third learning tasks 51

4.2 Mean trials to criterion for Conditions A, V, and C 52

4.3 Mean shift in performance between two subsequent conditions (1st minus 2nd) 52

4.4 Mean trials to learn 1st, 2nd, and 3rd eight word-pair list by method of presentation and hearing-loss group 54

4.5 Mean trials to criterion for first condition learned 55

4.6 Summary of analysis of the three methods of presentation 61

4.7 Summary of the analysis of variance on the V and C Condition and the five hearing-loss groups 61

4.8 Summary of the analysis of variance on trials to criterion for Conditions A, V, C and the three hearing-loss groups 62

4.9 Mean trials to criterion on Conditions A, V, and C for hard-of-hearing subjects and third and fourth grade normal-hearing subjects 63

5.1 Mean correct responses for twelve experimental groups in Experiment V 69

5.2 Summary of analysis of stimulus, response, and method of presentation variables 70

7.1 Mean correct responses for visual and auditory conditions on the two pairings of the word list 79

7.2 Mean numbers of correct responses on two lists over the first six trials for Conditions A and V 80

8.1 Mean numbers of correct responses as a function of grades and method of presentation 83

8.2 Mean trials to criterion for 5th and 6th grade subjects for the auditory and visual methods 84

LIST OF FIGURES

Figure Page

1.1 Mean trials for the eight successive word pairs, Condition A 17

1.2 Mean trials for the eight successive word pairs, Condition V 19

1.3 Mean trials for the eight successive word pairs, Condition C 21

1.4 Mean trials for the eight successive word pairs, Sub-conditions A - A, V - V, and C - C 23

1.5 Mean trials for the four successive word pairs, first task, A, V, and C 25

3.1 Mean trials to criterion on the eight word-pair list for grades 2, 3, 4, 7, 10; Sub-conditions A - A and V - A 39

3.2 Mean trials to criterion on the eight word-pair list for grades 2, 3, 4, 7, 10; Sub-conditions V - V and A - V 41

3.3 Mean trials to criterion on the eight word-pair list for grades 2, 3, 4, 7, 10; Sub-conditions A - A, V - V, and C - C 44

4.1 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 16-30 db loss group 56

4.2 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 31-45 db loss group 57

4.3 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 46-60 db loss group 58

4.4 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 61-75 db loss group 59

4.5 Mean trials for the eight successive word pairs; Sub-conditions V and C in the 76-90 db loss group 60

5.1 Mean number of correct responses per trial for the A, V, and C methods of presentation 72

Introduction

Much has been written about the advantages of a multisensory presentation of material to be learned. However, the capacity for utilization of multisensory stimulation is quite different when one sensory modality is markedly deficient. There is evidence that the aurally handicapped individual receives spoken communication much more efficiently when amplification permits him to "hear" as well as to see. One or another educator of the deaf and hard-of-hearing has claimed improvement in the reception of oral communication, in the development of speech, and in academic achievement when auditory stimulation is added to the training and teaching program. While these claims seem reasonable, there is relatively little in the experimental literature indicating that they have been put to a careful test.

Graunke (1952) initiated a doctoral research study under the supervision of the Principal Investigator of the present project. The purpose of the study was to explore the benefits of the addition of auditory stimulation to visual stimulation in a verbal-learning task. Specifically, groups of children learned to respond with a given word whenever its pair was presented as a stimulus. Each group of children learned two lists of ten paired-associate words. Under one condition the material was presented visually; in the other the words were presented visually and auditorily simultaneously. The visual presentation was made with a standard memory drum; the combined task utilized a magnetic tape recorder and amplifier in addition to the memory drum. The subjects were children at the third and fourth grade reading levels from the Public Schools and from the School for the Deaf in Illinois. Two main findings emerged:

a. Learning of the particular task under study was not faster with the combined method of presentation.

b. The method of preliminary practice seemed to influence which of the two methods was better with normal-hearing children.

The Graunke study showed that bimodal presentation does not necessarily lead to improved performance in all tasks with hearing-handicapped children. While the experimental task was too specific to permit general conclusions, the results clearly suggested an extension of the study. Several aspects seemed immediately relevant:

a. In the Graunke experiment, the normal children were included primarily as a control, and no attempt was made to describe normal behavior in the task under study. It is important to have a good understanding of how normal children perform on a paired-associate learning task when using audition or vision, or the two in combination, and when the method of presentation is first one, then another. With this background knowledge one can more adequately interpret the performance of hearing-handicapped children.

b. It is also important to determine the more absolute effect of a combined presentation with the hard-of-hearing. If additional study continues to reveal not only no improvement but the possibility of a decrement in performance, then further exploration of the use of the combined approach in the education of aurally-handicapped children would be in order.

c. Before definitive conclusions are drawn, it is important to know if the original results are specific to such variables as the age category of the normally hearing and to the degree of loss of hearing of the experimental group.

The present project was proposed as a study of verbal learning in children. The auditory and visual methods of presentation were to be the main variables. The plan was to use children in several age-grade groups in both the normal and hard-of-hearing categories. From such a study one could expect insight into an aspect of the learning process in normal children. In addition, an initial attack would have been made upon the problem of the place and use of amplification with hard-of-hearing children.

Objectives

The major objective of the present study was to conduct a basic investigation of a specific aspect of verbal learning using visual and auditory methods of presentation in children with normal hearing acuity and to relate the findings to the performance of hearing-handicapped children on the same tasks. More specifically, the plan included the following preliminary objectives:

a. The development of apparatus for presenting verbal-learning material in any one of three ways; viz, through vision alone (V), through audition alone (A), or through vision and audition in combination (C).

b. The development of lists of paired-associate words standardized for equivalence of learning difficulty for A, V, and C method of presentation.

In the conduct of the experiment, the learning tasks were to be presented to a large number of normal-hearing children and to the available hard-of-hearing children in the community. Through analysis of the results it was expected to find answers to the following questions:

a. Are there basic differences in the performances of normal children when learning paired-associate word lists by A, V, or C methods of presentation?

b. Are the performances of hearing-handicapped children equivalent to the normal in the various experimental conditions?

c. Are there differences in this type of learning which are related to the age-grade or intelligence classification of the children?

d. What are the effects of learning with one presentation method on immediate learning with another method of presentation?

e. Is there evidence that the bimodal method of presentation is superior to either auditory or visual alone?

A final objective was to utilize the findings of the studies as a basis to develop and test methods of auditory stimulation in the training of hard-of-hearing children. Experimental training sessions were to be planned and related to the experimental part of the study.

Related Research

The present project draws upon two main areas of research; verbal learning and the audio-visual method of teaching and training hard-of-hearing and deaf children. The literature in the area of verbal learning which pertains to the method of stimulus presentation indicates that, in general, the combined method of presentation is superior to either the auditory or visual methods alone. There is not good agreement on the superiority of either the auditory or visual methods. In a review of the literature Elliott (1936) pointed out that early investigations had indicated a superiority of the visual method over the auditory method of presentation, but that later studies had favored the auditory method. On the other hand, Kay (1958) reported that recall following visual presentation was superior to recall of auditorily presented materials. To the investigators' knowledge no experiment has been carried out where the A, V, and C methods of presenting paired-associate word lists have been varied systematically with laboratory apparatus.

The other area of research that provides background is the study of the use of the combined auditory-visual method of teaching hard-of-hearing and deaf children. A few studies are mentioned to illustrate and summarize the findings of this type of research.

Johnson (1948) reported an analysis of the performance of the pupils in the Illinois School for the Deaf according to the method of communication used; viz, Manual--signs and finger spelling; Oral--speech and lipreading without amplification; or Acoustic--speech and lipreading with amplification. She found that the group who had had the benefit of auditory stimulation in addition to lipreading was superior in reception of oral communication, in language facility, and in educational achievement.

One of the more extensive studies that has been carried out was a joint project of the Central Institute for the Deaf and the Clarke School for the Deaf. The Summary Report (1957) gives the following primary objectives of the study:

> To explore the possibilities of auditory training for profoundly deaf pupils, to determine the optimum design objectives of a modern group hearing aid, and to experiment in the field of methodology to determine practical methods for the employment of group hearing aids placed in the hands of skilled teachers.

The experiment was carried out over about a seven year period, and groups of children were followed closely for periods up to three years and then tested again annually as they remained in the school. The following quotations illustrate the findings:

> The evidence is clear that the combination of lipreading and hearing is nearly always more efficient than lipreading along.
>
> ...not only is speech perception improved by the auditory training program, but, in addition, speech intelligibility itself undergoes a gradual improvement under this program.
>
> ...an improved language development and a richer quality in general educational achievement.

This study generally attests to the advantages of a combined auditory-visual approach to the presentation of verbal material to deaf and hard-of-hearing children.

In 1951-52, Graunke searched for a method of studying the efficiency of the combined auditory-visual method of presentation in a laboratory-type experimental design. He decided that a simple initial approach to the problem would be to utilize the standard memory drum procedure for paired-associate learning as a visual task and to add synchronously an amplified pronounciation of the words from a magnetic tape recorder. In view of other research in the field, he assumed that learning would be accelerated under the combined approach. He used 6 groups of subjects, 12 per group. Four of the groups were from the Illinois School for the Deaf and were classified as severely hard-of-hearing or deaf. The other two groups were normal-hearing children. In one part of the experiment, four groups (one each of Acoustic, Oral, Manual, and Normal) were given practice with the visual method and then learned one list visually and another audio-visually. In the second part, two additional groups (Acoustic and Normal) were given combined practice and then learned the same two lists. As part of the design, the methods of presentation and the orders of presentation were counter-balanced.

In the first experiment where the practice had been visual, the performance was superior on the visual method of presentation in all four groups. The differences achieved significance at the 5% level for the Normal and Manual groups and at the 1% level for the Acoustic group. When the practice was audio-visual, the audio-visual learning was superior for the Normal group, but the visual was still superior for the Acoustic group. However, neither of these two differences was great enough to achieve statistical significance. As part of the analysis the data from the two independent groups of Acoustic and Normal children were pooled into an analysis of variance computation. For the Acoustic groups the between methods of presentation variance was significant, the visual being better than the combined. For the Normal groups the interaction term was significant, suggesting that the method of practice influenced the performance of the learning task. Some of Graunke's conclusions were as follows:

> The simultaneous presentation of test materials through two sensory channels did not emerge as a superior condition for learning, and the multi-channel presentation was probably inferior in several of the circumstances under investigation....These data would, therefore, lead one to conclude that the introduction of the auditory stimulus simultaneously with the visual in this type of learning task tended to interfere with the process of memorization.
>
> By observing the various performance scores for normals...one reasons that...they performed best on the mode of test which agreed with the mode of practice they were given.

> The results suggest that children with impaired hearing who have potential for substantial use of the auditory modality may experience some inhibition of efficiency when this modality is brought into play as a supplement to memorization of visually presented materials. It would appear that children with normal hearing do not face similar inhibition, but that their performance is dependent upon the set or aufgabe, of the moment.

Graunke cautions against a generalized interpretation of his results when he states, "The practical implications of the study are restricted to simple tasks of rote learning such as used here."

It is quite appropriate for Graunke to limit the interpretation that he makes of his data. However, it is interesting to consider his results in connection with certain statements made by Wedenberg (1954) after utilizing auditory training with severly hard-of-hearing children over a number of years. He states:

> The complete or partial loss of the auditory sense results in an ever greater concentration of the attention of the other senses and an intensification of their use. The unimpaired visual sense appropriates the greater part of the attention to the detriment of the impaired auditory sense. The residual hearing which exists is not rationally utilized....It is necessary to diminish the visual impression in order that the auditory stimuli may exercise a first claim upon the conscious....
>
> In many cases speech reading had already begun to play an important role for the child. It was therefore necessary to discourage it because, if a child grows too dependent upon speech reading, he never learns to listen....The handicap is gradually overtaken, however, by the "auditory trained", who are considerably more auditorily focused and therefore more normal.

In summary, a general review of the literature on audio-visual vs. visual training of hard-of-hearing and deaf children leads one to the conclusion that the combined approach is superior and contributes to improvement in the reception of communication, in the production of speech, and in achievement in academic subjects. However, there would appear to be exceptions, and rote verbal learning may be one. Furthermore, at least one study suggests that the best ultimate auditory performance is accomplished by initially suppressing the visual aspect rather than by adding the auditory to the visual.

The present project was planned as an extensive study of the interrelationships of auditory and visual presentations in one aspect of verbal learning. The underlying assumption was that the performances of hard-of-hearing children on these learning tasks can not be adequately evaluated until the performances of hearing children on the same tasks have been appropriately measured and defined.

Apparatus, Materials, Subjects, and Procedure

The apparatus used to present the word lists to both normal and hard-of-hearing subjects is described in this section. Subsequently, only reference will be made to the particular apparatus used in each experiment. In addition, this section presents a broad overview of procedures relevant to the selection and testing of subjects; specific details will be spelled out in the descriptions of individual studies.

1. Apparatus.

a. Visual apparatus. A modified Patterson S-Pa memory drum, Model 1-A, was used for visual presentations. The instrument utilized a rotating cylinder to which a continuous tape with the word pairs was attached. The stimulus and response words were typed side by side on the tape. A unit movement of the drum brought a pair of words to the viewing aperture, an opening 2 3/4 in. wide and 7/8 in. high. The stimulus word was immediately in view, but the response word was covered by a shutter. After the stimulus had been exposed for three seconds, a set of gears raised the shutter and exposed the response word simultaneously with the stimulus word for an additional three seconds. The shutter then closed while the drum rotated to the next pair of words. The word pairs were also presented visually with the electronic drum described below.

b. Auditory apparatus. For auditory presentations, the word pairs were recorded on magnetic tape. An Ampex, Model 601, tape recorder was used to record and play back the tapes. For the normally hearing subjects, the output of the tape recorder was matched with a transformer to a pair of Telephonic TD - 39 earphones. The recording level was adjusted to provide a comfortable listening intensity in the earphones. For the hard-or-hearing subjects, a Fisher, Model 20-A, 15 watt Amplifier, Model 250, and matching networks were added. The apparatus was capable of producing 118 db SPL measured with a 1000 cps tone recorded at the same level at which the speech material was recorded. The distortion in the system was not measured, but experienced listeners judged the quality to be good at all levels of presentation used in the study.

c. Combined apparatus. An electronically controlled drum was designed and built for the experiment by Gordon Stowe and Associates of Chicago (Arico). Basically the mechanical aspects of the drum were similar to the Patterson drum. However, the time cycle was controlled externally from the tape recorder. The drum and shutter were driven by two Hurst constant speed electric motors. The drum motor was held in a stall condition until an escapement mechanism was operated by a solenoid. The shutter motor was switched on with a relay to raise the shutter, and when the power was switched off, a spring returned the shutter to its rest position. The drum had an auxiliary control circuit built around two tuned filters such that a 1000 cps tone at 1 volt would activate the solenoid escapement mechanism and a 500 cps tone at 1 volt would switch the shutter motor.

The other part of the combined apparatus was an Ampex 601-2 tape recorder. This is a two-channel recorder. The stimulus words were recorded on one channel, and alternate bursts of 500 and 1000 cps tones were recorded on the second channel.

When the apparatus was assembled for operation, the speech channel was used to carry the stimulus words either directly to the earphones or through an amplification system identical to the one described in paragraph b. above. The channel carrying the bursts of pure tones was connected to the control box of the memory drum. Since the drum and shutter operated only when triggered by the recorded bursts of tone, the memory drum became the slave of the tape recorder. Once the tones and words were properly recorded, the auditory and visual stimuli were in automatic synchronization.

The combined equipment was used upon occasion for auditory or visual presentations by disconnecting either the memory drum or the subject's headset.

2. Test Materials. Three lists of four word pairs each and sixteen lists varying from eight to ten word pairs were constructed. The lists are presented in Appendix B. Originally, three lists of four word pairs each and nine lists of eight word pairs each were assembled from a large list of monosyllabic nouns of three to five letters each. None of the words were above the fourth grade vocabulary level. The eight word-pair lists were standardized for auditory or visual presentation according to the procedure outlined in Appendix A. The four and eight word-pair lists were used for Experiments I through IV.

Four additional lists of ten word pairs each were constructed for use in Experiment V. Twenty 4-letter words, classified as nouns, and twenty 4-letter words, classified as both nouns and verbs were selected from the Thorndike and Lorge (1944) "AA" frequency list. All words were of third grade difficulty or less. Four lists of ten word pairs each were then constructed with the noun (S) and noun-verb (D) words. The words were assigned to either the stimulus or the response position as follows: S - S, S - D, D - D, D - S.

One ten-pair word list of four-letter nonsense syllables was constructed for use in Experiment VI. Twenty syllables were formed with the restriction that they would be pronounceable but would not readily be associated by sight or sound with any meaningful word. These syllables were paired so as to minimize associative value as judged by the experimenters.

The remaining two test lists were constructed from the list of D - D pairs mentioned above. The first list was the result of a random selection of five word pairs from the D - D list. A second list of words, was then constructed by a shifting of the response words so that new pairs were formed, but the stimulus and response words remained as stimulus or response members. These lists were used in Experiment VII.

3. Subjects. The subjects were chosen from among children attending representative schools in the Metropolitan Detroit Area.

The children used in Experiments I, II, and III were all screened for hearing acuity with a pure tone sweep test at 15 db re normal threshold and for adequate vision using the Spache Binocular Reading Test (1943). In addition, Raven's Progressive Matrices (1938) were administered as a group test. Children were accepted when they passed both the hearing and vision tests and scored between the 25th and 75th centiles on Raven's test, with the exception that in Experiment II subjects from the 0-15 and 85-100 centile ranges were used.

Children in Experiment IV were placed into one of five hearing loss groups on the basis of pure tone audiometric test findings. Pure tone thresholds of the better ear were used to categorize the subjects. Specifically, hearing loss categories of 16-30, 31-45, 46-60, 61-75, and 76-90 db were chosen. A child fit a category when the average of his hearing levels for 500, 1000, and 2000 cps was within the category boundaries; when two of the three frequencies of concern were within the boundaries; and when the loss for the high frequencies was not sharply different from the general trend of the audiogram.

Children in Experiments V through VIII were chosen from various grades in schools selected to cooperate in the study. Subjects whose academic achievement was judged as normal and who were known to have no marked sensory deficiencies were chosen at random from the specified grades.

In all, nearly 2500 subjects were used in the project.

4. Procedure. Experimental sessions were conducted in the schools where the children were in attendance with the exception of several hard-of-hearing children who were tested during a summer session at the Wayne State University Hearing Clinic.

All children were administered the learning tasks individually with the exception of subjects in Experiment VIII. The general procedure was as follows:

The subject was brought into a room and seated facing the apparatus. Then, a demonstration of the general nature of the task was given along with the specific instructions for the particular testing procedure. The subject was assured that his performance on this task was not related to his school work. The subject was then given one trial on which he was presented each of the word pairs in the test list being used. This familiarized the subjects with the word-pair test procedure and also gave the experimenters an opportunity to correct any problems in pronunciation. Scored trials were then started, a trial being one presentation of all the word pairs in the list. In the experiments where trials-to-criterion was the measure (I through IV) the subjects continued with the learning task until they reached the trial in which they correctly anticipated the response member of each word pair. If a subject was unable to meet this criterion within 30 trials, the session was terminated, and a score of 30 arbitrarily assigned. In Experiments V through VIII, all subjects received the same number of trials, and the measure of performance was the total number of correct responses.

In each study, with the exception of Experiment VIII, the experimenter sat to the side and back of the subject and recorded responses on prepared data sheets. In Experiment VIII, the subjects wrote their responses.

Retention tests were administered to all available subjects one week following original testing in Experiments I through IV. The stimulus words from the eight word-pair list had been typed on 3" x 5" cards. As the stimulus word was shown to the subject it was pronounced by the experimenter. The words were presented in a random serial order, and the subject's task was to give the appropriate response word. The experimenter recorded correct responses.

Results of the Experiments in Verbal Learning.

The main findings from the entire project are presented in this section, which is organized into subsections corresponding to separately-designed experiments.

A. Experiment I. Effect of Method of Presentation.

1. Introduction and Hypothesis. In Experiment I, a list of 4 word pairs was presented by each of three methods of presentation (A, V, C). A second list of 8 word pairs was then presented by each method of presentation. The sensory modality through which the second list of paired words was presented identifies a condition. Each condition, e.g., auditory, had 3 sub-conditions, determined by the sensory presentation of the first list. The sub-condition in which the first and second word lists were presented through the same sensory modality was the reference sub-condition for the other two. Thus, Condition A, Sub-condition A, designated A - A, was the Reference Sub-condition for the Sub-conditions V - A and C - A. Similarly, Conditions V and C had Reference Sub-conditions V - V and C - C for the Sub-conditions A - V and C - V, and A - C and V - C, respectively. The experiment was designed to determine if learning of the second list was influenced by the method of presentation of the first list.

Three separate studies, differing only with respect to method of presentation of the second list, were conducted to investigate these effects. The hypotheses may be summarized as follows:

a. The number of trials required to learn the second list of the three reference sub-conditions would not be significantly different.

b. In a given condition, fewer trials would be required to learn the second list of the reference sub-condition than would be required to learn the second list in either of the other two sub-conditions.

c. Retention scores for reference sub-conditions would be higher than for other sub-conditions.

2. Plan of the Experiment. Three separate studies were conducted in which the experimental designs were identical. Three Conditions (A, V, and C) and two learning tasks (four- and eight-pair word lists) constituted the basic variables in the present studies. The design may be conceived of as follows:

	Condition A	Condition V	Condition C
Sub-Condition A	A - A	A - V	A - C
Sub-Condition V	V - A	V - V	V - C
Sub-Condition C	C - A	C - V	C - C

Two-hundred and seventy pupils from 9 Detroit Public Schools served as Ss. All Ss had previously been found to have normal vision and hearing and to have scores on Raven's Progressive Matrices falling between the 25th and 75th centiles. All Ss were naive with regard to verbal-learning procedures.

A S first was given instructions and then a practice trial on which he was allowed to see the 4 word pairs of List #1. Following this, the test trials were begun. After the four-word list had been learned, the 8 word pairs of List #4 were presented for a practice trial and then repeatedly presented until the list was learned. For both lists, the word pairs were presented until the S correctly anticipated all the response words on one trial; if a S failed to meet this criterion in 30 trials, the particular task was stopped. A trial was a presentation of the entire list.

The lists were presented visually with the Patterson and electronic memory drums and auditorily with the two Ampex recorders.

3. Findings.

a. Auditory Condition. The mean numbers of trials required to learn the four and eight word-pair lists are shown in Table 1.1 for all sub-conditions of

Condition A. Separate 1 x 3 analyses of variance[1] were performed on the four-pair and the eight-pair list scores; the resulting F values of 1.58 and .77 respectively with 2/87 df failed to reach statistical significance. A Pearson product-moment correlation coefficient computed on the four- and eight-pair test scores yielded an r = + .37, which was significant at the .01 level with 88 df. A subsequent analysis of covariance[2] failed to reach significance (F = 1.74, df = 2/86).

TABLE 1.1.--Mean trials to learn the lists under Condition A.

Sub-conditions	n	Four-pair	Eight-pair
A - A	30	8.3	11.5
C - A	30	9.1	12.7
V - A	30	6.9	13.4

Learning curves were drawn using a transformation of the data suggested by Underwood (1949). The successive coordinate values indicate the mean numbers of trials required to attain at least one correct word-pair, two correct word-pairs, and so on.

Figure 1.1 shows the learning curves for the three sub-conditions. The eight-pair means given in Table 1.1 correspond to the values of the end points

---

1. Bartlett's test (1937) for homogeneity of variance was used in all the analyses of variance reported throughout the Results Section of this study. In each instance where X^2 was significant, a (B) was placed behind the reported F value and the probability of that F was doubled to take into account the existence of heterogenity of variance.

2. Since preliminary analyses revealed a number of low, but significant correlations between the number of trials required to learn the first and second lists as well as between the number of trials required to learn the second list and retention scores, coefficients of correlation were calculated for these variables in Experiment I. Whenever the coefficient of correlation was significantly different from zero, an analysis of covariance was performed.

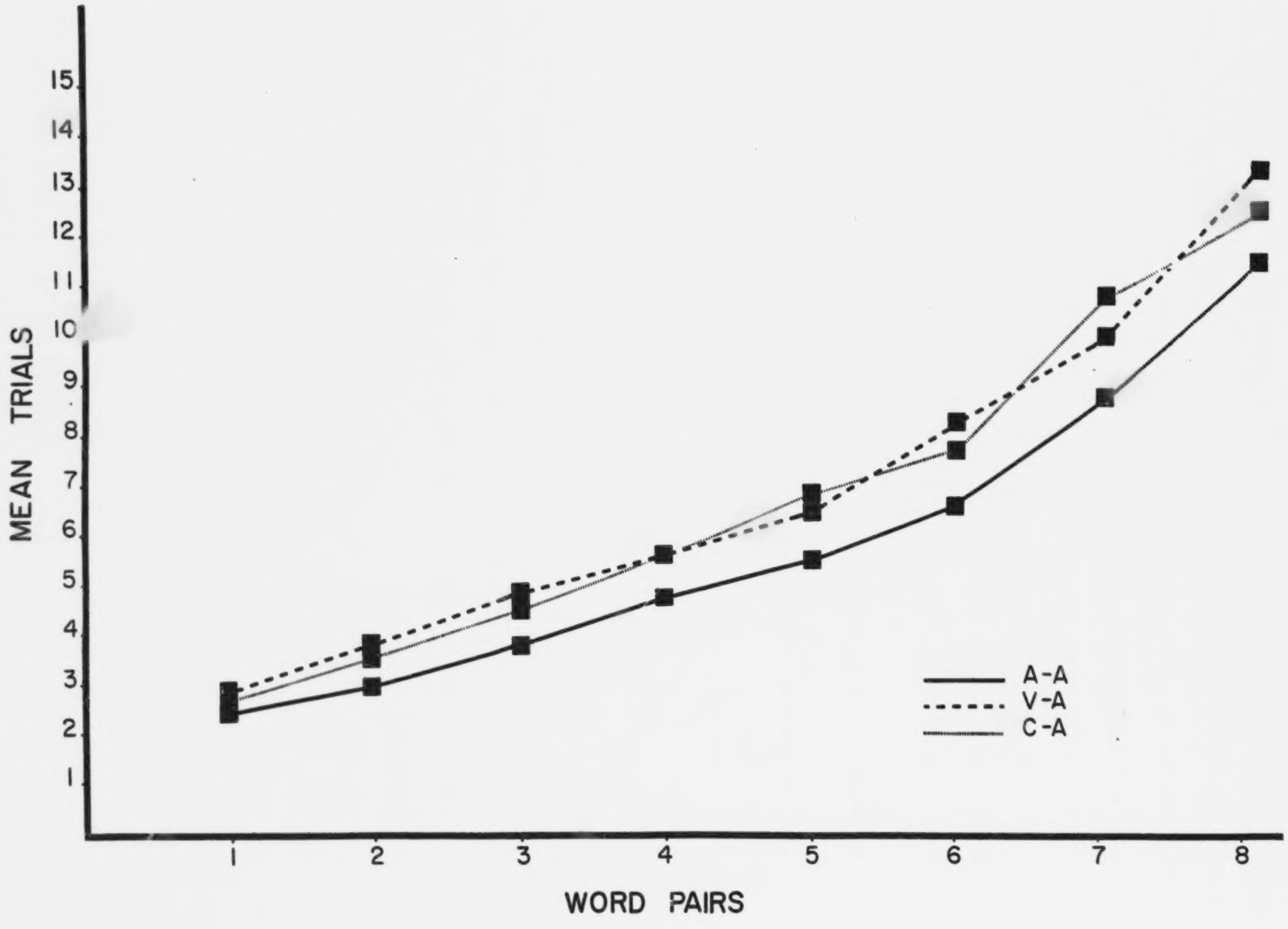

Fig. 1.1 Mean trials for the eight successive word pairs, Condition A.

shown in this figure. The figure reveals that subjects in Sub-condition A - A consistently reached each word-pair criterion in fewer trials than subjects in Sub-conditions V - A and C - A. The curves for the V - A and C - A Sub-conditions merely indicate random fluctuations in relative superiority.

b. Visual Condition. Table 1.2 presents the mean numbers of trials required to learn the four- and eight-pair word lists for the three sub-conditions. The scores were subjected to 1 x 3 analyses of variance; F values of .57 and .18 respectively with 2/87 df indicated no statistically reliable differences. The coefficient of correlation (r = + .17) was not significant.

TABLE 1.2.--Mean trials to learn the lists under Condition V.

Sub-conditions	n	Four-pair	Eight-pair
V - V	30	7.3	10.9
C - V	30	6.8	11.2
A - V	30	7.9	11.7

Figure 1.2 shows the learning curves for the three sub-conditions. Inspection of the figure rather clearly reveals the similarity of the scores of the three sub-conditions.

c. Combined Condition. The mean numbers of trials required to learn the four- and eight-pair word lists in Condition C are presented in Table 1.3.

TABLE 1.3.--Mean trials to learn the lists under Condition C.

Sub-conditions	n	Four-pair	Eight-pair
C - C	30	7.7	10.7
A - C	30	9.8	10.8
V - C	30	6.0	13.6

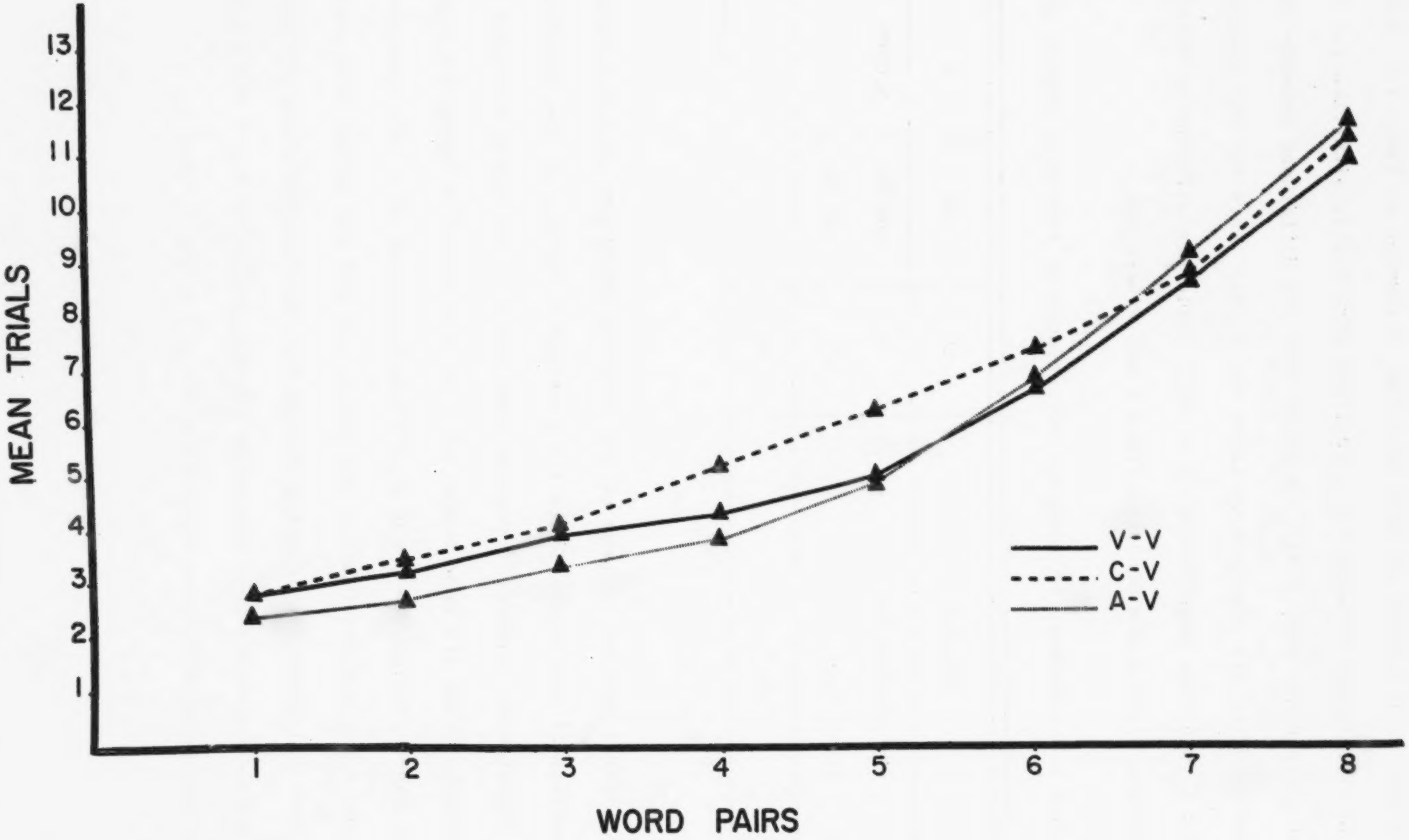

Fig. 1.2 Mean trials for the eight successive word pairs, Condition V.

A simple 1 x 3 analysis of variance was performed on the four-pair list scores. The summary of this analysis, presented in Table 1.4, indicated that the differences between sub-conditions were highly significant. The Duncan Multiple Range Test (1955) revealed that the difference between the mean number of trials required to learn the 4-pair lists for Sub-conditions V (6.0) and A (9.8) was significant (P = .01), while the differences between Sub-conditions C and A and Sub-conditions C and V were not.

TABLE 1.4.--Summary of analysis of variance of four-pair scores under Condition C.

Source	df	MS	F
Sub-conditions	2	108.84	5.00**
Error (w)	87	21.76	
Total	89		

**P = .01

The eight-pair scores of the combined condition were subjected to a 1 x 3 analysis of variance. Table 1.5 presents a summary of the analysis and shows a significant variance among sub-conditions. The Duncan Multiple Range Test indicated that the mean number of trials required to learn the eight word pairs for Sub-condition V - C was significantly greater (P = .05) than for Sub-conditions A - C and C - C while the latter two did not differ from each other. Figure 1.3 shows the learning curves for the sub-conditions of Condition C. The figure reveals that the curve for Sub-condition V - C was consistently deviant from curves for Sub-conditions A - C and C - C.

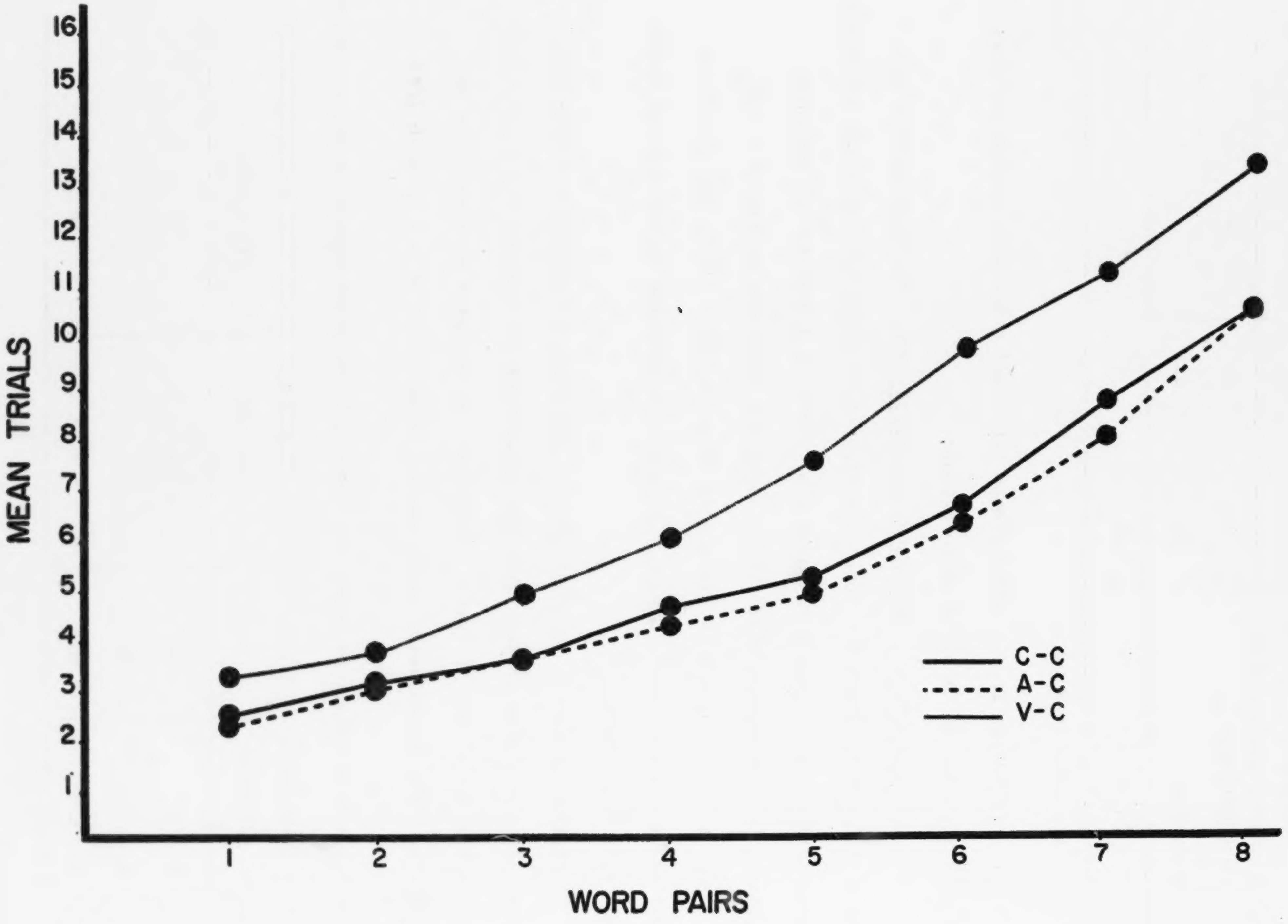

Fig. 1.3 Mean trials for the eight successive word pairs, Condition C.

TABLE 1.5.--Summary of analysis of variance of eight-pair scores under Condition C.

Source	df	MS	F
Sub-conditions	2	81.24	3.94*
Error (w)	87	20.65	
Total	89		

*P = .05

The correlation (r = + .05) between four- and eight-pair scores obviates the necessity for an analysis of covariance.

d. Comparison of Reference Sub-conditions. The mean numbers of trials required to learn the four- and eight-pair lists for the three reference sub-conditions are repeated in Table 1.6. Two 1 x 3 analyses of variance indicated no significant differences among the four-pair scores (F = .42, df = 2/87), nor among eight-pair scores (F = .24, df = 2/87), for the three reference sub-conditions. Figure 1.4 shows the learning curves for the three eight-pair word lists.

A Pearson product-moment correlation was computed between the four-pair and eight-pair scores of the three sub-conditions and yielded r = + .24, which was significant at the 5% level. Therefore, an analysis of covariance was performed. The new adjusted value was not significant (F = 2.59 with 2/86 df).

TABLE 1.6.--Mean trials to learn the lists for the three reference sub-conditions.

Sub-conditions	n	Four-pair	Eight-pair
A - A	30	8.3	11.5
V - V	30	7.3	10.9
C - C	30	7.7	10.7

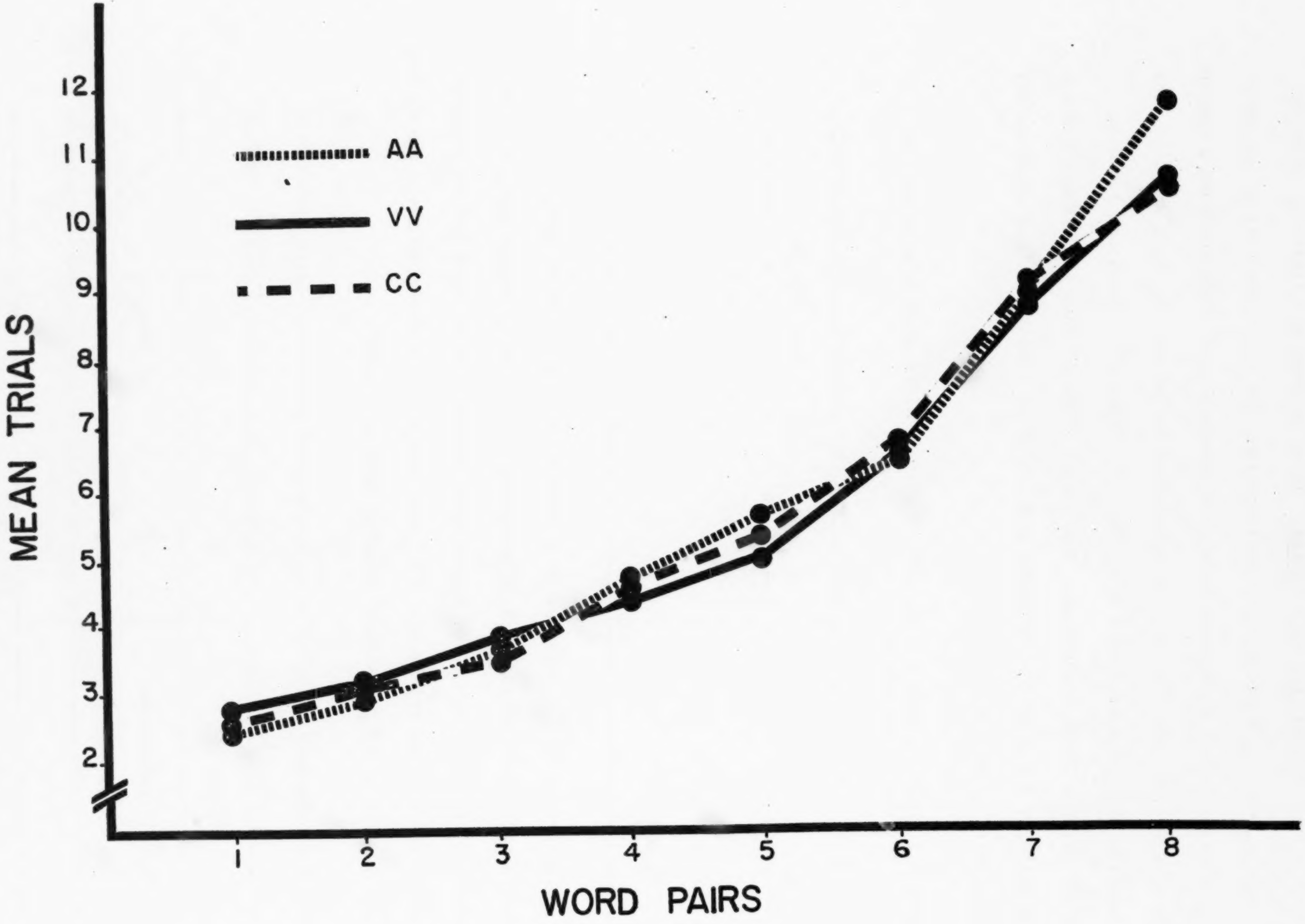

Fig. 1.4 Mean trials for the eight successive word pairs, Sub-conditions A - A, V - V, and C - C.

e. Pooled Four-Pair Scores. In an attempt to assess the efficacy of the three methods of stimulus presentation, the four-pair list scores were pooled according to A, V, or C method of presentation. This involved a combining of the four-pair list scores represented in Tables 1.1, 1.2, and 1.3. The composite means are presented in Table 1.7. Figure 1.5 shows the learning curves for the three conditions. The curves revealed that the V Condition was consistently superior to Conditions C and A while Condition C was consistently superior to Condition A.

TABLE 1.7.--Mean trials to learn the four-pair lists according to method of presentation.

Conditions	n	Mean Trials
A	90	8.7
V	90	6.7
C	90	7.9

The scores were analyzed with a simple 1 x 3 analysis of variance. The results presented in Table 1.8 indicate significant differences among the three methods of presentation. The Duncan Test indicated that the V method required significantly fewer trials (P = .05) than the A method but that the A and C, and C and V methods did not differ reliably from each other.

TABLE 1.8.--Summary of analysis of variance of pooled four-pair list scores.

Source	df	MS	F
Between Conditions	2	87.00	4.50*
Error (w)	287	19.34	
Total	289		

*P = .05

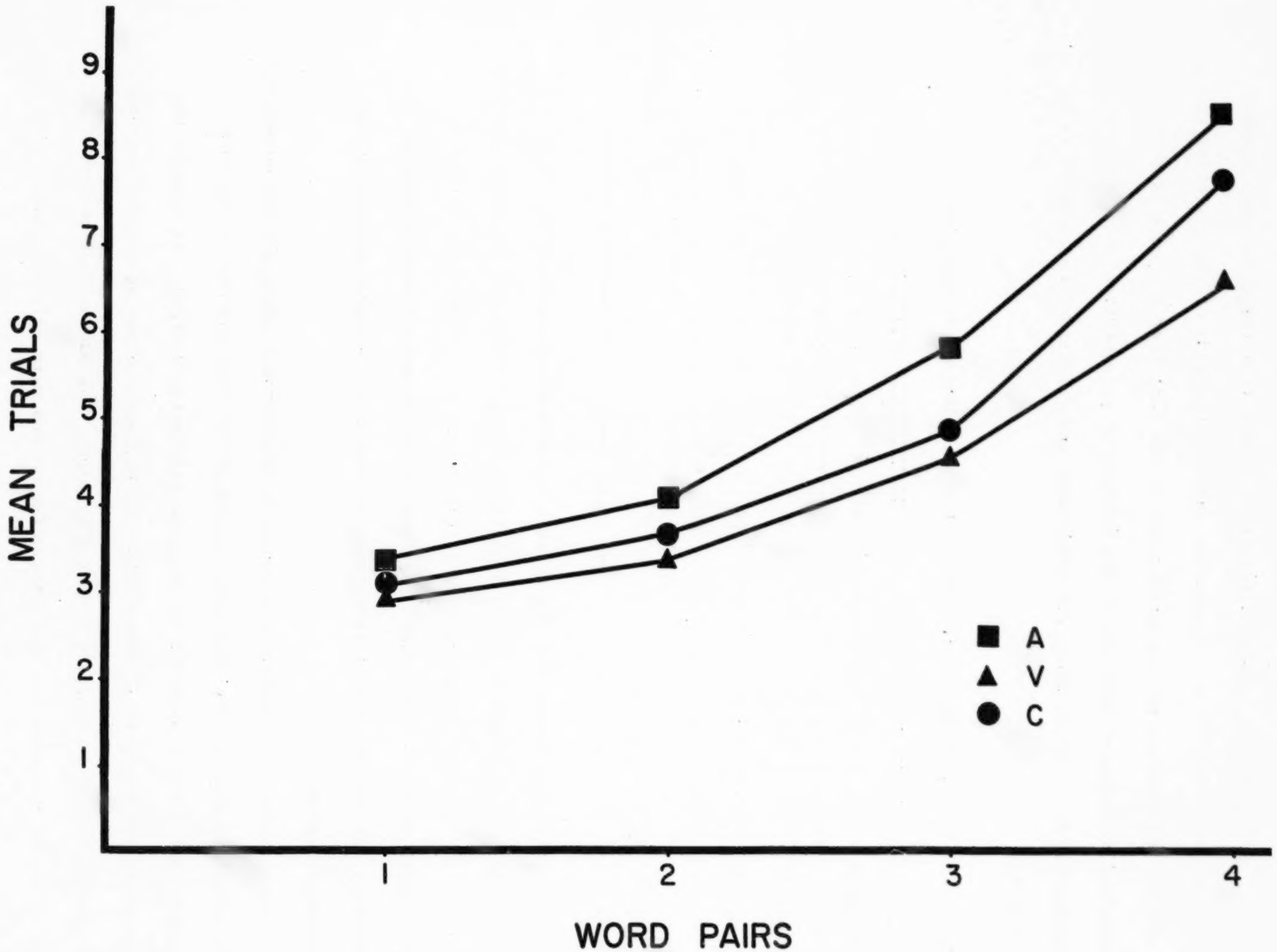

Fig. 1.5 Mean trials for the four successive word pairs, first task, A, V, and C.

f. Retention. All the retention scores from the three main studies are presented in Table 1.9. A separate analysis was made of the retention scores of the three reference sub-conditions due to the fact that subjects in these groups had experienced only one of the methods of presentation and therefore no complicating interaction among sub-conditions and retention score needed to be considered.

TABLE 1.9.--Retention scores for the nine sub-conditions in Experiment I.

Condition A	n	$\overline{X}$	Condition V	n	$\overline{X}$	Condition C	n	$\overline{X}$
A - A	30	5.5	V - V	30	3.7	C - C	30	5.1
V - A	24	5.9	A - V	29	4.4	A - C	30	5.4
C - A	28	5.1	C - V	28	5.3	V - C	30	4.8
Condition Means		5.5			4.1			5.1

The retention scores for the three Reference Sub-conditions (A - A, V - V, and C - C) were analyzed by a 1 x 3 analysis of variance. The analysis revealed that the differences failed to reach significance (F = 2.48, df = 2/87). A correlation of r = - .17 between test and retention scores contraindicated the necessity for an analysis of covariance to evaluate the differences among the retention scores.

In an attempt to analyze the possible relationship among all sub-conditions and retention scores, the retention scores of the nine sub-conditions were entered into a 3 x 3 analysis of variance (factorial design). As seen in the summary of the analysis in Table 1.10, the Between Conditions main effect and the sub-condition interaction were significant. The Duncan Test performed on the A, V, and C scores for the Between Conditions main effect revealed that the subjects who learned under Condition A retained significantly more word pairs (P = .05) than the subjects who learned under Condition V. No significant difference was found in comparisons of Conditions A and C or Conditions C and V. With regard to the interaction term, inspection of the sub-condition means shows that retention was best in Sub-condition V - A while it was poorest in Sub-condition V - V. The retention scores of Condition A appear to be least effected by the sub-condition variable.

TABLE 1.10.--Summary of analysis of retention scores according to various sub-conditions.

Source	df	MS	F
Sub-condition (SC)	2	1.34	.50
Condition (C)	2	19.00	7.14 (B)
SC x C	4	8.68	3.26*
Error (w)	216	2.66	
Total	224		

(B) P = .02

* P = .05

4. Discussion. Experiment I was designed to study the effect of method of sensory presentation upon the learning of paired-associate word lists. One hypothesis was that there would be no difference among auditory, visual, or audio-visual methods of presentation. A comparison of the reference sub-conditions (A - A, V - V, and C - C) supported the hypothesis. The evidence must be interpreted with caution for the reason that all 8 word-pair lists were originally standardized on fourth-grade children using both A and V presentations. In the process of standardization, adjustments were made in the lists so that the numbers of trials required to learn them were about equal. Therefore, the fact that there was no difference between trials-to-learn list

#4 for A - A and V - V is a corroboration of the standardization procedure. However, the C - C Sub-condition was not considered in the standardization, and it was found not significantly better than A - A or V - V.

The results obtained with the four word-pair lists are relevant to the hypothesis of no differences among A, V, and C. The analyses of the trials required to learn the shorter list show that under visual presentation 6.7 trials were required on the average, and under the auditory presentation 8.7 trials were required. The difference was significant. This suggests that the visual presentation of a short word list is slightly superior in fourth-grade children.

The original eight word-pair standardization presentation of first make-up of the lists showed A to be superior to V on 8 of the 9 lists. The magnitude of the differences was not great, but the initial impression was that the auditory method of presentation was at least as efficient as the visual.

In summary, Experiment I does not give unequivocal evidence for either A or V. The inference of no difference is the most tenable from this experiment alone. The evidence is much more clear that the combined method of presentation is not superior to either the auditory or visual methods of presentation.

A second hypothesis was that it would take more trials to learn the second list when the method of presentation was different for the second than for the first list than it would when the method of presentation was the same for both lists. In general, statistical corroboration of this hypothesis failed to materialize. However, there was evidence that suggests further study is necessary before the hypothesis is completely rejected. The evidence was as follows:

a. In Condition A, Figure 1.1, the Sub-condition A - A is deviant from Sub-conditions V - A and C - A throughout the curves. Although the mean total trials to learn were not different among the three sub-conditions, inspection suggests that further study of the Condition is needed.

b. In Condition C, the Sub-condition V - C was significantly poorer than Sub-conditions C - C and A - C. Incidentally, Sub-condition V - C approximated the arrangement of presentations under which Graunke found a significant difference.

The third hypothesis of Experiment I was that the retention scores would be equivalent for all sub-conditions. Statistical analysis revealed differences which were significant. Specifically, retention scores for Condition A were better than for Condition V. Before practical significance is given to this finding, further studies should be performed. This is especially true since other experiments in the present project did not corroborate the finding.

B. Experiment II. Effect of "Ability"

1. Introduction and Hypothesis. Several studies concerned with the intellectual development of the hearing impaired child indicate that he is deficient in reasoning ability by comparison with the normal child. One particular test on which the two groups of children differ is Raven's Progressive Matrices (1938), a test purported to measure abstract reasoning ability.

Oleron (1950) and Fuller (1959) report studies using the Progressive Matrices in which the test results from hearing impaired children were compared with the test norms. In Oleron's study, 56.8% of the scores fell below the twenty-fifth centile of the norms, and 48% of the scores fell below the twentieth centile. Fuller reported that 47.7% of the subjects in his sample (6 - 12 years of age) ranked at or below the twentieth centile and that, "the median raw score for the deaf children is lower than the median score of hearing children one year younger."

Inasmuch as hard-of-hearing children tended to score in the low centile range of the Progressive Matrices and since studies reported below were to be concerned with a comparison of normal and hard-of-hearing children, it was decided to study the relationship between scores on the Progressive Matrices and scores on the verbal learning task.

Therefore, Experiment II was designed to test the hypothesis that the number of trials required to learn a paired-associate word list would be greater for children with low scores on Raven's test than for children with high scores.

2. *Plan of the Experiment*. Forty 4th grade *S*s scoring in the 0 - 15 centile range on the Progressive Matrices and forty 4th grade *S*s scoring in the 85 - 100 centile range were randomly assigned to five experimental conditions in which two 8 word-pair lists were presented. The restriction was imposed that 8 *S*s from both centile groups be assigned to each of the five conditions. The design may be conceived of as follows:

0 - 15 Centile Group			85 - 100 Centile Group		
First List		Second List	First List		Second List
A	------	A	A	------	A
V	------	A	V	------	A
V	------	V	V	------	V
A	------	V	A	------	V
C	------	C	C	------	C

Four *E*s were used in the experiment; each tested 4 *S*s per condition, two from each centile group. Retention scores were obtained on all *S*s one week later.

The subjects were fourth grade children from five different public schools in Detroit who had previously been administered Raven's Progressive Matrices as part of the selection procedure for Experiment I and who had scores which fell in one of the two centile groups defined on the previous page. All Ss were naive with regard to verbal learning procedures.

The subjects were first given the standard instructions, one practice trial and then 10 test trials on the first paired-associate list. They were then presented a second list and were required to learn it to a criterion of one trial on which all response words were correctly anticipated. List #6 was used as the first list, and List #4 was the second list.

Presentations were made with the Patterson memory drum, the electronic memory drum, and the two Ampex tape recorders.

3. Findings. The mean numbers of trials required to learn the second list are presented in Table 2.1 for the 10 experimental sub-conditions.

TABLE 2.1--Mean trials to criterion for high and low centile groups in five sub-conditions.

Group	Sub-Conditions					Centile Mean
	A - A	V - A	V - V	A - V	C - C	
High Centile	10.2	15.0	7.1	12.6	11.0	11.2
Low Centile	9.5	20.4	14.2	17.0	7.9	13.8
Sub-Condition Means	9.9	17.7	10.7	14.8	9.4	

A 2 x 5 x 4 analysis of variance (factorial design) was used for the experiment. The variables were: high and low centile groups, five sub-conditions, and four experimenters. Table 2.2 presents the summary of the associated analysis of variance. The analysis indicated there were significant differences among the means for the five sub-conditions but there was no significant difference between centile groups.

The means for the five sub-conditions were as follows: C - C= 9.4;

A - A= 9.9; V - V= 10.7; A - V= 14.8; V - A= 17.7. The Duncan Test indicated that C - C and A - A were significantly smaller than V - A, while none of the remaining comparisons were significant.

TABLE 2.2--Summary of analysis of variance for the 2 centile groups, 5 sub-conditions, and 4 experimenters.

Source	df	MS	F
Sub-Conditions (SC)	4	207.25	4.47**
Centile Groups (CG)	1	135.20	2.92
Experimenters (E)	3	14.13	.30
SC x CG	4	75.20	1.62
SC x E	12	74.68	1.61
E x CG	3	66.26	1.43
SC x CG x E	12	21.48	.46
Error (w)	40	46.35	
Total	79		

**P = .01

A 1 x 5 analysis of variance was employed in order to analyze the scores of the 5 sub-conditions for each centile group. The analysis of the high centile group revealed no differences among the 5 sub-conditions, (F was 1.76 for 4/35 df). However, for the low centile group, the analysis indicated a significant difference among the scores. The resulting F of 3.95 (df = 4/35) was significant at the .01 level. The Duncan Test indicated that the means for Sub-conditions C - C and A - A were smaller than the mean for Sub-condition V - A, and that the mean for Sub-condition C - C was also smaller than the mean for Sub-condition A - V, all at the .05 level of significance.

None of the remaining possible comparisons was significant. Table 2.3 summarizes the 1 x 5 analysis of variance for the low centile group.

TABLE 2.3.--Summary of analysis of variance for the 5 sub-conditions in the low centile group.

Source	df	MS	F
Between Sub-conditions	4	214.54	3.95^{**}
Within (w)	35	54.26	
Total	39		

$^{**}P = .01$

The mean retention scores for each of the 10 sub-conditions are presented in Table 2.4. A simple 1 x 2 analysis of variance was performed on the scores for the high and low centile groups and is summarized in Table 2.5. The variance ratio for between centile groups was significant. As shown in Table 2.4, the high centile group had retention scores of 5.5 contrasted to scores of 4.5 for the low centile group.

TABLE 2.4.--Mean retention scores for the 5 sub-conditions and the 2 centile groups.

Group	Sub-Conditions					Centile Mean
	A - A	V - A	V - V	A - V	C - C	
High Centile	5.8	5.0	5.5	5.8	5.5	5.5
Low Centile	5.1	3.1	4.6	4.1	5.4	4.5

TABLE 2.5.--Summary of analysis of retention scores for high and low centile groups.

Source	df	MS	F
Between Groups	1	21.02	7.73^{**}
Error (w)	78	2.72	
Total	79		

**P = .01

Even though the between sub-conditions variance ratio was significant for the learning task (Table 2.2), an analysis of the retention scores by conditions failed to yield a significant F value (F = 1.79, df = 4/75).

4. Discussion. The hypothesis of the experiment was that the number of trials required to learn a paired-associate word list would be greater for children with low scores on the Progressive Matrices than for children with high scores. Five sub-conditions were used. When the trials-to-learn were averaged for all five sub-conditions, the hypothesis was not supported. The mean for the low-centile group is 13.8, and the mean for the high-centile group was 11.2. However, the difference was not statistically significant.

The mean difference, favoring the high-centile group, was not consistent for all five sub-conditions; the low-centile group had the better averages for Sub-conditions A - A and C - A.

When the sub-conditions were analyzed within centile groups, no significant differences were found for the high-centile group. The three best scores were for the Reference Sub-conditions: V - V, A - A and C - C, in that order. Further study is necessary before significance should be attached to these differences.

For the low-centile group, there were significant differences among the sub-conditions. The best average scores were on C - C and A - A; the poorest were on V - A and A - V. The inference made is that children who score lowest on the Progressive Matrices have not yet achieved the ability to function well in a visual presentation of a verbal task. Furthermore the shift from V to A or A to V results in much poorer performances. These shifts also produce the poorest results in the high-centile group, but the difference is not as marked.

The retention scores for the low-centile group were consistently poorer than the retention scores for the high-centile group in all five sub-conditions. Since Experiment II was the only one using subjects selected by high or low scores on Raven's test, further study would be necessary to determine what, if any, relationship exists between the two variables.

C. Experiment III. Effect of Grade Placement

1. Introduction and Hypothesis. The original plan of the project was to carry out a basic study of paired-associate verbal learning in one age-group (fourth grade) and then to conduct additional studies of paired-associate learning in other age-groups. The results obtained from children in other grades were expected to limit or extend the generalities of the findings in the fourth grade and to supply additional normative data for judging the performance of the hard-of-hearing.

It is possible that the fourth grade level represents the transition point between auditory and visual preference and that the subjects are sufficiently flexible that they can accomodate and switch from A to V and V to A without difficulty. On the other hand, in lower grades where reading ability is being developed or in upper grades where this ability is highly developed, children may not adapt to the change of stimulus presentation as readily. For instance, it was assumed that the number of trials required to learn the second list in the A - V Sub-condition in the second and third grades, and the V - A Sub-condition in the seventh and tenth grades would be greater than the number of trials required to learn the list under the appropriate reference sub-condition.

The second main purpose of Experiment III was to gather reference data on subjects from several grades. It was assumed that the learning and retention performances would improve by grade from second through tenth.

In summary, Experiment III was designed to test the following hypotheses:

a. There would be a general improvement in the performance of subjects on the learning tasks with increase in grade level.

b. In the second and third grades performance would be best on Condition A.

c. In the seventh and tenth grades better performance would be obtained on Condition V.

d. In Sub-conditions V - A and A - V the performances would be poorer than the performances on the reference sub-conditions.

e. Retention scores would be best for the highest grades and for the reference sub-conditions.

2. *Plan of the Experiment*. Select groups of subjects from the 2nd, 3rd, 7th, and 10th grades were randomly assigned to each of the five sub-conditions, namely: A - A, V - A, V - V, A - V, and C - C. Each subject was tested in only one of the grade sub-condition categories. One week after testing, all subjects were tested for retention.

List #6 was used as the first list, and List #4 was used as the second list. The lists were presented with the Patterson and electronic memory drums and with the two Ampex tape recorders.

A total of 300 subjects from public schools in the Detroit Area participated in the study, 75 from each of the 4 above listed grades. Only children who scored between the 25th and 75th centiles on Raven's Progressive Matrices and who had normal hearing and adequate vision were used as subjects. All subjects were naive with regard to the verbal-learning task.

The procedure was identical to that described in Experiment II.

3. Findings.

a. Auditory Condition. The mean numbers of trials required to learn the eight word-pair list under the A - A and V - A Sub-conditions are shown in Table 3.1. As seen from the table, each grade level required more trials to learn the second list under Sub-condition V - A. The scores of these subjects were entered into a 2 x 5 analysis of variance (factorial design). The summary of the analysis presented in Table 3.2 revealed that the average difference of 3.4 trials favoring the reference sub-condition is statistically significant. The Mean Square for grades was also highly significant.

TABLE 3.1.--Mean trials to learn the eight word-pair list under Condition A.

	Sub-Conditions	
Grade	A - A	V - A
2	16.9	20.9
3	16.4	19.6
4*	10.7	13.5
7	11.6	14.2
10	6.3	10.9
Col. mean	12.4	15.8

*Fifteen scores from each of the A - A, V - V, C - C, V - A, and A - V Sub-conditions in Experiment I were selected at random and formed the basis for the 4th grade results in the present study.

TABLE 3.2.--Summary of analysis of Sub-conditions (A - A and V - A) for five grade levels.

Source	df	MS	F
Sub-conditions (SC)	1	440.33	11.51**
Grades (G)	4	554.55	14.50 (B)
SC x G	4	5.34	.14
Error (w)	140	38.25	
Total	149		

**P = .01
(B) P = .02

The Duncan Test revealed that the pooled means for Sub-conditions A - A and V - A for grades 2 and 3 were not significantly different from each other, but that they were significantly poorer (P = .02) than the pooled means for the other three grades. Grades 4 and 7 did not differ from each other, but both grades were poorer than grade 10 (P = .02). The interaction Mean Square was not significant, thereby corroborating the consistency of the superiority of Sub-condition A - A over V - A throughout the grades. Figure 3.1 presents the corresponding learning curves.

b. Visual Condition. The mean numbers of trials required to learn the eight-word list with the V - V and A - V Sub-conditions are shown in Table 3.3. As revealed by the column means, there was no difference between the two sub-conditions. A 2 x 5 analysis of variance (factorial design) was performed on

TABLE 3.3.--Mean trials to learn the eight word-pair list under Condition V.

Grade	Sub-Conditions	
	V - V	A - V
2	24.1	21.6
3	15.1	15.0
4	9.0	10.2
7	10.2	10.7
10	8.5	9.7
Col. mean	13.4	13.4

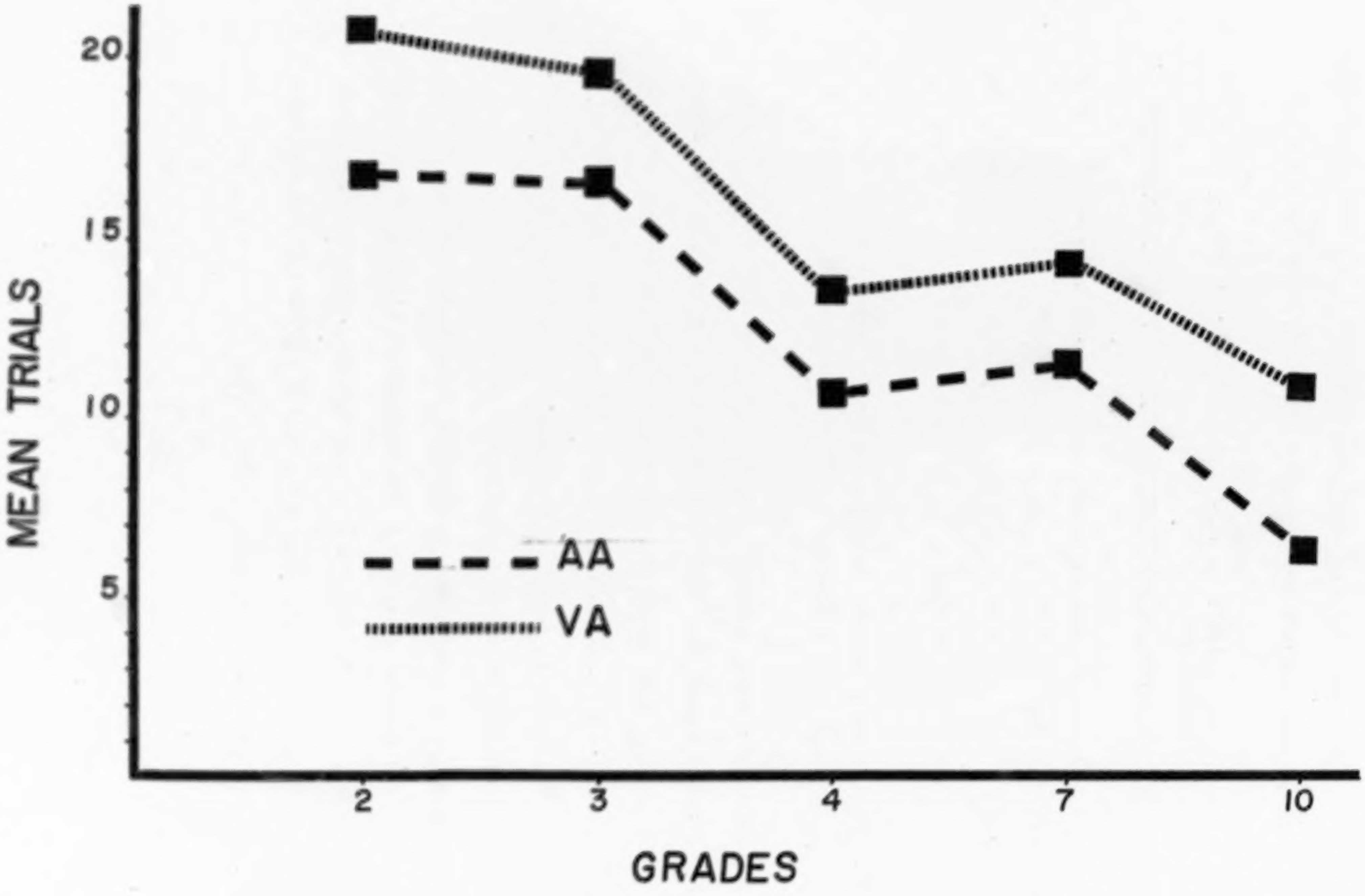

Fig. 3.1 Mean trials to criterion on the eight word pair list for grades 2, 3, 4, 7, 10; Sub-conditions A - A and V - A.

the scores of these two sub-conditions. The analysis summarized in Table 3.4 revealed that only the grades Mean Square was significant. The Duncan Test on the means of the grades revealed that the combined V - V and A - V means for the 2nd grade were significantly higher (P = .02) than the combined means of each of the other grades. In addition, the mean of the 3rd grade was significantly higher (P = .05) than the means for the 7th and 10th grades. The latter three means did not differ from each other. The curves of grades by sub-conditions shown in Figure 3.2 indicates that neither sub-condition was consistently superior throughout the grades. This fact is revealed statistically by the non-significant interaction.

TABLE 3.4.--Summary of analysis of sub-conditions (V - V and A - V) for five grade levels.

Source	df	MS	F
Sub-condition (SC)	1	.08	-
Grades (G)	4	1,004.46	28.81 (B)
SC x G	4	17.69	.51
Error (w)	140	34.86	
Total	149		

(B) P = .02

c. Comparison of Conditions by Grades. A primary interest of the present study was the relation among the methods of sensory presentation for several grades. Table 3.5 gives scores for the reference sub-conditions for grades 2, 3, 4, 7, and 10. The A - A and V - V scores are the same as those used in previous analyses.

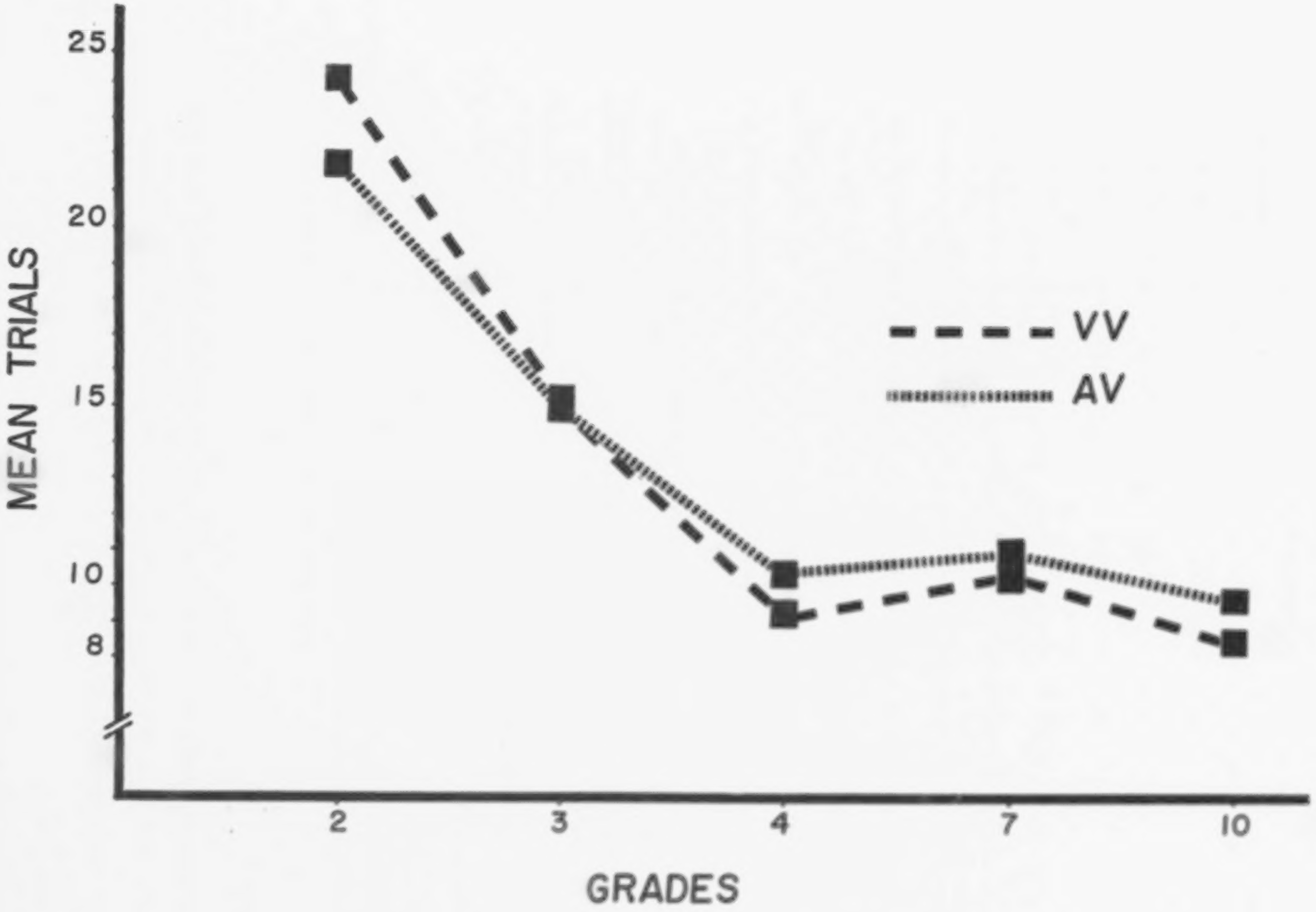

Fig. 3.2 Mean trials to criterion on the eight word-pair list for grades 2, 3, 4, 7, 10; Sub-conditions V - V and A - V.

TABLE 3.5.--Mean trials to learn the eight word-pair list for reference sub-conditions in five grades.

Grade	Sub-conditions			Row Mean
	A - A	V - V	C - C	
2	16.9	24.1	15.5	18.8
3	16.4	15.1	16.1	15.8
4	10.7	9.0	9.9	9.8
7	11.6	10.2	8.2	10.0
10	6.3	8.5	9.0	7.9
Col. Mean	12.4	13.4	11.7	12.5

A 3 x 5 analysis of variance (factorial design) was performed on the scores from the reference sub-conditions. As shown in Table 3.6 the grades main effect and the interaction of sub-conditions x grades were significant. The Duncan Test performed on the means of pooled scores for each grade revealed that the 2nd grade required more trials to learn the list than the 3rd grade (P = .05) and than the 4th, 7th, and 10th grades (P = .02). Furthermore, the 3rd grade required more trials than the 4th, 7th, and 10th grades

TABLE 3.6.--Summary of analysis of scores from Reference Sub-conditions A - A, V - V, and C - C for five grade levels.

Source	df	MS	F
Sub-conditions (SC)	2	52.90	1.86
Grades (G)	4	959.52	33.74^{**}
SC x G	8	90.99	3.20 (B)
Error (w)	210	28.44	
Total	224		

**P = .01

(B) P = .02

(F = .02), while the latter three did not differ significantly from each other. The curves for conditions by grades is shown in Fig. 3.3.

The main thing to be noted from the curves is that there was an improvement in performance for all reference sub-conditions up to the fourth grade and only slight improvement in the higher grades. Furthermore, none of the reference sub-conditions was consistently superior throughout the grades.

d. Retention. The mean numbers of correct responses on the retention task for each of the three reference sub-conditions are shown in Table 3.7. As will be seen from the column means, the largest mean difference among reference sub-conditions when all grades were averaged was .6 response. The coefficient of correlation of +.11 contraindicates the necessity of an analysis of covariance between scores on the second list and retention scores. Therefore, a 3 x 5 analysis of variance (factorial design) was performed on the retention scores. As suggested from inspection of the row and column means in Table 3.7, the analysis revealed no significant differences between grades (F = .90, df = 4/210).

TABLE 3.7.--Mean correct responses on retention test for three reference sub-conditions and five grade levels.

Grade	Sub-conditions			Row Mean
	A - A	V - V	C - C	
2	5.3	4.0	4.3	4.5
3	4.9	4.7	4.5	4.7
4	4.7	4.6	4.6	4.6
7	5.1	5.1	4.9	5.0
10	5.5	5.0	4.3	4.9
Col. mean	5.1	4.5	4.5	4.7

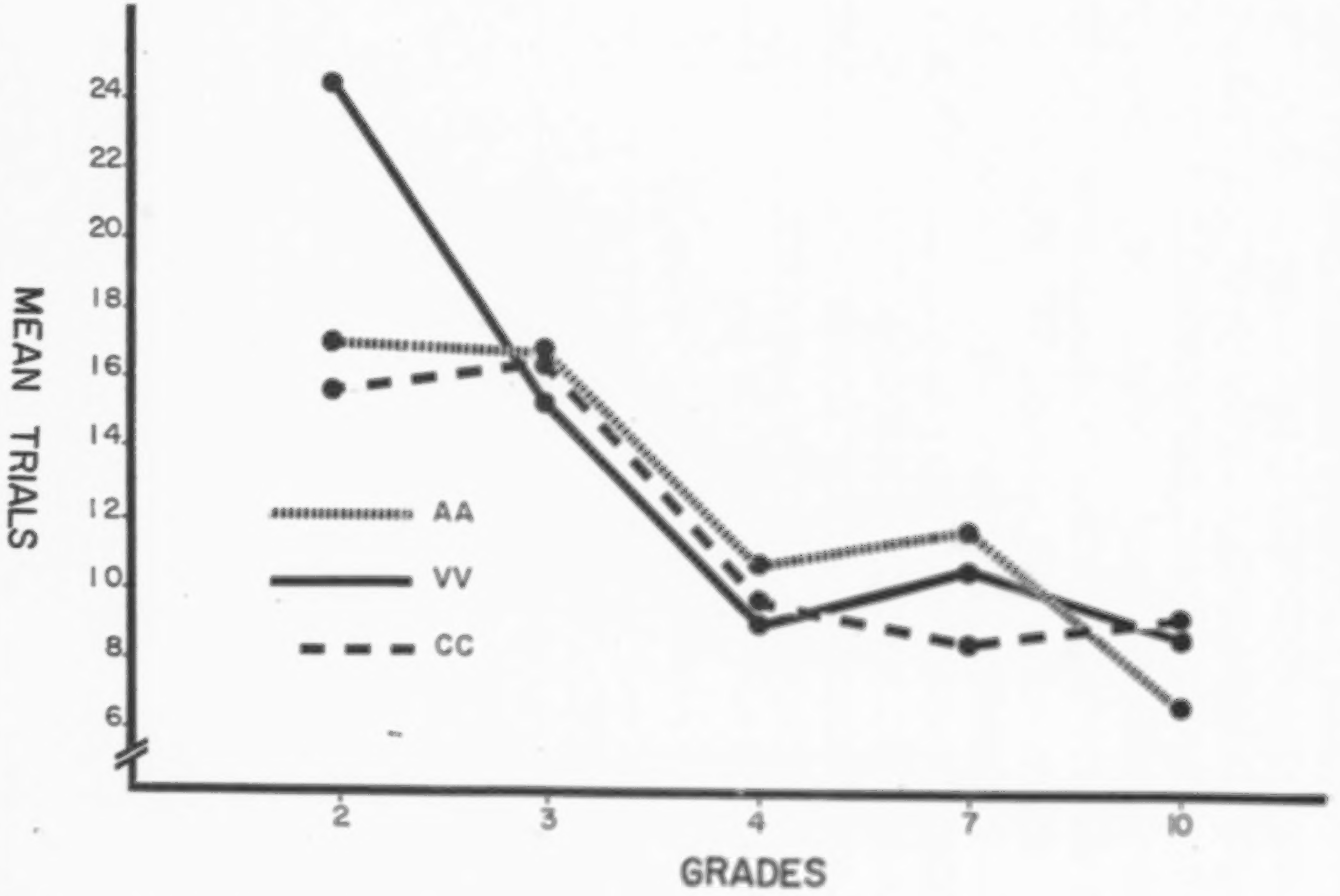

Fig. 3.3 Mean trials to criterion on the eight word-pair list for grades 2, 3, 4, 7, 10; Sub-conditions A - A, V - V, and C - C.

e. Discussion. There were four main hypotheses formulated in Experiment III. The first was that there would be a general improvement in the performance of subjects on the learning task with increase in grade level.

The data failed to support a differential effect throughout the grades when the modality is changed between the first and second lists. In the A - A and V - A Sub-conditions the performance is consistently better when the two lists are presented in the same way. The differences between the sub-conditions are statistically significant. In Experiment I, Figure 1.1, the curves for both V - A and C - A showed poorer performances than does the curve for A - A, although the differences measured by the end points were not significant. The most direct interpretation is that school children do not shift readily from visual to auditory stimulation on a paired-associate verbal-learning task. The performance decrement would appear to be reliable and fairly consistent. It seems possible that the factors which produced the differences were not the same. In the second grade there were several children who were not familiar with all the words on the lists. As shown in Table 4.5, Grade 2 required about 8 more trials on the average to learn the list with visual presentation than with either the auditory or the combined methods. One finds also that the second grade groups are the ones to show a mentionable difference favoring A - V over V - V. It appears likely that the additional difficulty in reading the words observed in Grade 2 was a factor in the performance. This explanation is untenable for the upper grades; therefore, even though the present data do not offer a clear clue, other explanations need to be sought in further research.

The experiment comparing A - V and V - V Sub-conditions requires little comment. The differences between conditions were not significant as is clearly revealed in Fig. 3.2. The fact that the lower grades did slightly better on A - V than on V - V while the upper three grades did slightly better on V - V would have to be corroborated by further research before being given serious consideration.

The curves representing average performances on Sub-conditions V - V, A - A, and C - C by grades show very little change from grade to grade above the fourth grade. It would appear that an extension of the sample would yield an asymptotic curve for the visual condition starting to level off by the fourth grade. If this observation were true, it is important for it suggests that the massive data collected by experimental psychologists on college students is probably generally valid for children down to about the fourth grade providing the complexity of the task is appropriate to the age level. Interestingly, the graduate assistants on whom the experimenters practiced initially, performed little better than the fourth grade children on the learning tasks.

There was no improvement in performance between the second and third grades for the A and C Conditions. The superiority of A and C Conditions over the V Condition is reasonable in the second grade. However, the failure to show improvement between the second and third grades is not in keeping with the general trend of the data. As mentioned earlier, the third grade is conceivably the beginning of the transition between auditory and visual learning of verbal material in school. Further research might give clues on how best to aid the transition.

One important variable that may have exerted an influence on the results is the inherent difference in the visual and auditory stimuli. The visual stimuli were present for the full duty cycle; i.e., 6 seconds for the stimulus and 3 seconds for the response word. The auditory stimuli were merely pronounced, therefore, they were actually present only about 1 second each. Furthermore, the visual pairs appeared side by side on the drum, which might be expected to produce a natural "paired" set. The auditory pairs do not provide such a natural paired association. The problem was given consideration in the original design of the study, but pilot studies suggested that the variation was not critical. Studies now being planned will give further consideration to this problem.

The finding that the retention scores were essentially equivalent in all grades and conditions is particularly interesting. One conclusion from the data is that, when children are brought to an identical criterion of learning, retention is equivalent in all grades tested. On the other hand, more exposures were necessary to produce the same amount of retention in the earlier grades. For instance, the second grade and tenth grade children both remembered an average of 5 word pairs under the C - C Condition yet the second grade children had a mean of 15.5 trials while the tenth grade group had only 9.0 trials on the average. When the mean number of exposures are divided into the number of pairs retained, the quotient is a percentage index of efficiency. The resultant quotients are .26, .30, .47, .51, and .64 for the grades tested from second to tenth respectively. In summary, the data suggest that retention may be considered equal across the grades but that greater amounts of practice are necessary to achieve a constant value from which to calculate the retention.

D. Experiment IV. Effect of Hearing Loss.

1. Introduction and Hypothesis. An important part of the present project was a study conducted on children with hearing losses. All sub-conditions were of interest in this study. Due to the limited number of hard-of-hearing subjects available, it was decided to test each child on three word-pair lists using the A, V, and C methods. Use of this procedure allowed an investigation of possible

effects of learning a word list with one method of presentation upon subsequent learning of a second list presented by another method.

The experiment was designed to provide tests of the following hypotheses:

a. It was predicted that the general performance of the hearing-loss groups would be approximately equal to that shown by the normal-hearing groups.

b. It was predicted that significant differences would appear among the A, V, and C Conditions; specifically, that Condition A would be the poorest, being essentially normal for the mild hearing-loss group but becoming impossible for some of the groups with greater hearing losses.

2. Plan of the Experiment. Five hearing-loss categories, three methods of stimulus presentation, and six test orders formed the basic variables in the present experiment. Pure tone thresholds of the better ear were used to categorize the subjects. Specifically, hearing-loss categories of 16-30, 31-45, 46-60, 61-75, and 76-90 db were chosen. A child met the category requirements when the average of his hearing levels for 500, 1000, and 2000 cps was within the category boundaries; when two of the three frequencies of concern were within the boundaries; and when the loss for the frequencies above 2000 cps was not sharply different from the general trend of the audiogram. Records of hard-of-hearing children were screened until 30 children per category were located who also had reading achievement scores indicative of about third grade ability or above.

The A, V, and C Conditions were arranged into six test orders: A-V-C, A-C-V, V-A-C, V-C-A, C-A-V, and C-V-A. The subjects within each hearing-loss category were randomly assigned to the six test orders with the limitation that five subjects be presented each order. Therefore, 10 subjects in each hearing-loss category were presented the first word list with the A, V, or C methods respectively. Four-word List #1 and eight-word Lists #4, #5, and #6 were used for the study. The eight-word lists were randomly assigned among the conditions.

The 150 children used in the study were obtained from the two Day Schools for the Deaf, the Residential School for the Deaf, and from the Public Schools, all in the city of Detroit. A few hard-of-hearing children were obtained from the suburban programs. All children had had several hearing tests. Raven's test and the vision tests were administered as part of the selection procedure.

For the administration of the auditory and combined conditions, the intensity of the stimuli was adjusted to a comfortable listening level. Specifically, a series of paired digits was presented from the tape recorder through the amplification system and the headset. The subject was instructed to repeat the digits, and a 75% correct threshold was determined. The intensity was then increased until the subject voluntarily reported that the digits were "too loud." Both values were recorded. The settings for the test material were as near the "too loud" value as the subject would accept as comfortable. The sensation level for the presentation of the material varied from about 40 db for the milder hearing-loss groups to about 19 db for the groups with the severest losses. Since most of the subjects either wore hearing aids or had been exposed to fairly extensive auditory training experiences, the establishment of the various levels was not difficult. When the subjects could not discriminate the digits, "awareness" levels were used.

All subjects were presented the four word-pair list as the initial learning task. Just prior to beginning the learning task, each subject was shown the stimulus and response words in a random serial order. He was asked to pronounce each word on the list. This procedure allowed E to become familiar with the speech pronunciations of the child. Each subject was read the instructions for the verbal-learning task. Then the subject was presented the word pairs for one trial. Following this, the subject continued the task to one perfect trial or a maximum of 20 trials, whichever came first. Upon completion of the four word-pair list, each subject was shown a random serial list of the stimulus and response words from the first eight word-pair list. The procedure for this list and each subsequent list was exactly as described for the four-word list with the exception that subjects were allowed a maximum of 30 trials to learn the list. The four word-pair introductory list was presented by the same method used in presenting the first eight word-pair list; namely A, V, or C. When a subject was unable to discriminate the words presented auditorily, he was arbitrarily given 15 trials and encouraged to learn any word pairs he might understand. All subjects were tested on the four word-pair list and the 3 eight word-pair lists in a single day. At the end of each of the first and second eight word-pair lists learned, the child was allowed to return to his room for about an hour before being brought back to learn another list.

Retention scores were obtained a week later, at which time each subject was presented the stimulus words from all three lists in a random serial order.

3. Findings. A total of 150 hard-of-hearing subjects from five hearing-loss groups each learned 1 four word-pair and 3 eight word-pair lists of paired-associate words under three (A, V, and C) conditions. Within each hearing-loss group, the 30 subjects were assigned randomly to one of the six possible arrangements of the A, V, and C Conditions. Lists #4, #5, and #6 were used in such a way that the order and conditions under which the lists were learned were counterbalanced. The basic data, which were collected, will be presented first and described briefly, and then the statistical treatments will be given and discussed.

a. Summary of Learning Data. One of the factors that contributed to the number of trials required to learn a list of paired-associates was "learning the requirements of the task." If the subjects continued to improve from list to list, it would confound some of the analyses. Therefore, the data were tabulated so that means could be calculated for the first, second, and third list learned without regard to other variables. Table 4.1 summarizes the findings. There was no systematic tendency for the scores to change appreciably over the three learning tasks. The group with the least hearing loss was the only one which appeared to profit from the experience with the task; the others did poorest on the second list. Inasmuch as the three lists and the A, V, and C Conditions occur equally in the columns, their effects are counterbalanced. In view of the findings here, no further consideration was given to order of presentation in other analyses.

TABLE 4.1.--Mean trials to criterion for the first, second, and third learning tasks.

H-L in db.	N	Order			Row Mean
		1st	2nd	3rd	
16 - 30	30	13.9	12.7	11.9	12.8
31 - 45	30	12.3	15.5	12.3	13.4
46 - 60	30	13.2	15.3	13.3	13.9
61 - 75	20*	12.0	12.4	13.2	12.5
76 - 90	20*	10.6	12.2	11.2	11.3
Col. Mean		12.4	13.6	12.4	12.8

*Auditory condition not included.

The data were rearranged to calculate the effect of the condition of learning when the variables of lists and order of presentation of A, V, and C were pooled. Table 4.2 gives the summary. Clearly, Condition C was not superior to the visual method in the total group. In the sub-groups, the scores favored Condition C for the milder hearing losses and Condition V for the more severe cases. Learning under Condition A was poorest for all groups, the difference became progressively greater as the hearing loss increased.

Another way of looking at the same data is to calculate the change in

TABLE 4.2.--Mean trials to criterion for Conditions A, V, and C.

H - L in db.	N	Condition			Row Mean
		A	V	C	
16 - 30	30	15.4	12.2	10.9	12.8
31 - 45	30	17.3	11.9	11.0	13.4
46 - 60	30	18.4	11.1	12.3	13.9
61 - 75	30	21.3*	12.0	13.1	15.5
76 - 90	30	----**	10.9	11.7	11.3
Col. Mean		18.1	11.6	11.8	13.6

*n = 9

**No *S*s learned the list

performance which occured between two successive conditions. For instance, in the six permutations of A, V, and C there were the orders A-V-C and C-A-V. Therefore, ten subjects learned a list visually after just learning one auditorily. Each subject's performance can be expressed as being better or worse on the second task than on the first. Table 4.3 summarizes these cal-

TABLE 4.3.--Mean shift in performance between two subsequent conditions (1st minus 2nd)*

H-L in db.	N	A - V	V - A	A - C	C - A	V - C	C - V
16 - 30	10	+ .5	- 1.7	+ 10.1	- 3.2	+ .8	+ .7
31 - 45	10	+ 7.6	- 7.7	+ 13.7	- 5.3	- .2	- 3.0
46 - 60	10	+ 3.2	- 13.0	+ 9.6	- 4.3#	- .5	+ 1.1
61 - 75	10	---	----	---	---	+ .7	+ 2.5
76 - 90	10	---	----	---	---	+ .7	+ 1.2
Mean$_{1.3}$**		+ 3.8	- 7.5	+ 11.1	- 4.3	+ .03	- .4
Mean$_{T}$		—	—	—	—	+ .3	- .5

*The scores were calculated by subtracting the trials to criterion on the second lettered condition from the first. A positive value indicates improvement.

**Means based only on 1st three hearing-loss groups.

#Two *S*s did not learn to criterion, and values of 30 were assigned to the A Condition.

2

culations. The finding of most interest here was the consistency with which differences appeared in sub-conditions among the various hearing-loss groups. Condition V was better than Condition A no matter which came first (columns 1 and 2). However, the sequence showing the greatest relative improvement was the Sub-Condition A - C. This particular order needs further investigation.

It was not clear from Table 4.3 whether the differences which appeared between adjacent conditions were due to sequence effects or were inherent in the method of presentation or both. Therefore, the data were tabulated in terms of the first, second, or third learning task by method of presentation and hearing-loss groups. Table 4.4 gives these results. The means presented here are a breakdown of those presented in Table 4.2 so that the 1st, 2nd and 3rd test conditions are represented. Thus, the row means (right column) in Table 4.4 correspond to the column values in Table 4.2. As inferred from the data in Table 4.1, there was little evidence of an order effect. However, inspection of Table 4.4 suggests a possible exception in the auditory condition #2. When the auditory presentation was second it made the greatest contribution to the size of the means of Condition A. Since the auditory condition is the poorest, it is possible that it would also be the most susceptible to the effects of shifting to it after practicing with a visual or combined presentation. Three things stand out from an inspection of tabulations:

1) Condition A produced the poorest scores.
2) Results from Conditions C and V were consistent among all hearing-loss groups.
3) Learning under Condition C was not superior to learning under Condition V.

TABLE 4.4.--Mean trials to learn 1st, 2nd, and 3rd eight word-pair list by method of presentation and hearing-loss group.

Auditory

H-L in db.	N	1	2	3	Row Mean
16 - 30	10	16.7	15.2	14.2	15.4
31 - 45	10	13.3	25.1	13.4	17.3
46 - 60	10	18.4*	21.0	15.7#	18.4
61 - 75	10	20.4**	----	23.0##	----
76 - 90	0	----	----	----	----
Col. Mean		17.2	20.4	16.6	

* n = 9, # n = 8, ** n = 6, ## n = 3.

Visual

16 - 30	10	12.6	12.3	11.7	12.2
31 - 45	10	10.8	12.4	12.4	11.9
46 - 60	10	10.3	11.8	11.3	11.1
61 - 75	10	11.0	11.1	13.8	12.0
76 - 90	10	10.6	12.8	9.3	10.9
Col. Mean		11.1	12.1	11.7	

Combined

16 - 30	10	12.5	10.6	9.7	10.9
31 - 45	10	12.9	9.1	11.0	11.0
46 - 60	10	10.8	13.2	12.8	12.3
61 - 75	10	13.0	13.7	12.7	13.1
76 - 90	10	10.5	11.6	13.1	11.7
Col. Mean		11.9	11.6	11.9	

b. _Statistical Analysis of the Data_. One 1 x 3 and two 1 x 5 analyses of variance were performed on the number of trials required to learn the first eight word-pair list. The analysis of Condition A was limited to the 16-30, 31-45, and 46-60 db loss groups. The latter two analyses involved Conditions V and C respectively for all hearing-loss groups. Table 4.5 shows the mean trials to criterion for each group, and Figures 4.1 through 4.5 present learning curves drawn from the data.

TABLE 4.5.--Mean trials to criterion for the first condition learned.

H-L in db	N	Conditions		
		A	V	C
16 - 30	10	16.7	12.6	12.5
31 - 45	10	13.3	10.8	12.9
46 - 60	10	18.4	10.3	10
61 - 75	10	----	11.0	13.0
76 - 90	10	----	10.6	10.5
Col. Mean		16.1	11.1	12.8

The results of the three analyses of variance are summarized in Table 4.6. Clearly, there were no significant differences among the means within a single condition.

A second group of analyses were designed to search for differences among the conditions. The fact that it was not possible to obtain scores on all the subjects in the 61-75 and 76-90 db hearing-loss groups under Condition A precluded a 3 x 5 analysis. However, all the subjects in the Conditions V and C were able to complete the task. A 2 x 5 analysis of variance (factorial design) was utilized in order to analyze Conditions V and C and the five hearing-loss groups. Table 4.7 summarizes the analysis of variance. As previously inferred from inspection, Conditions V and C did not produce significantly different results.

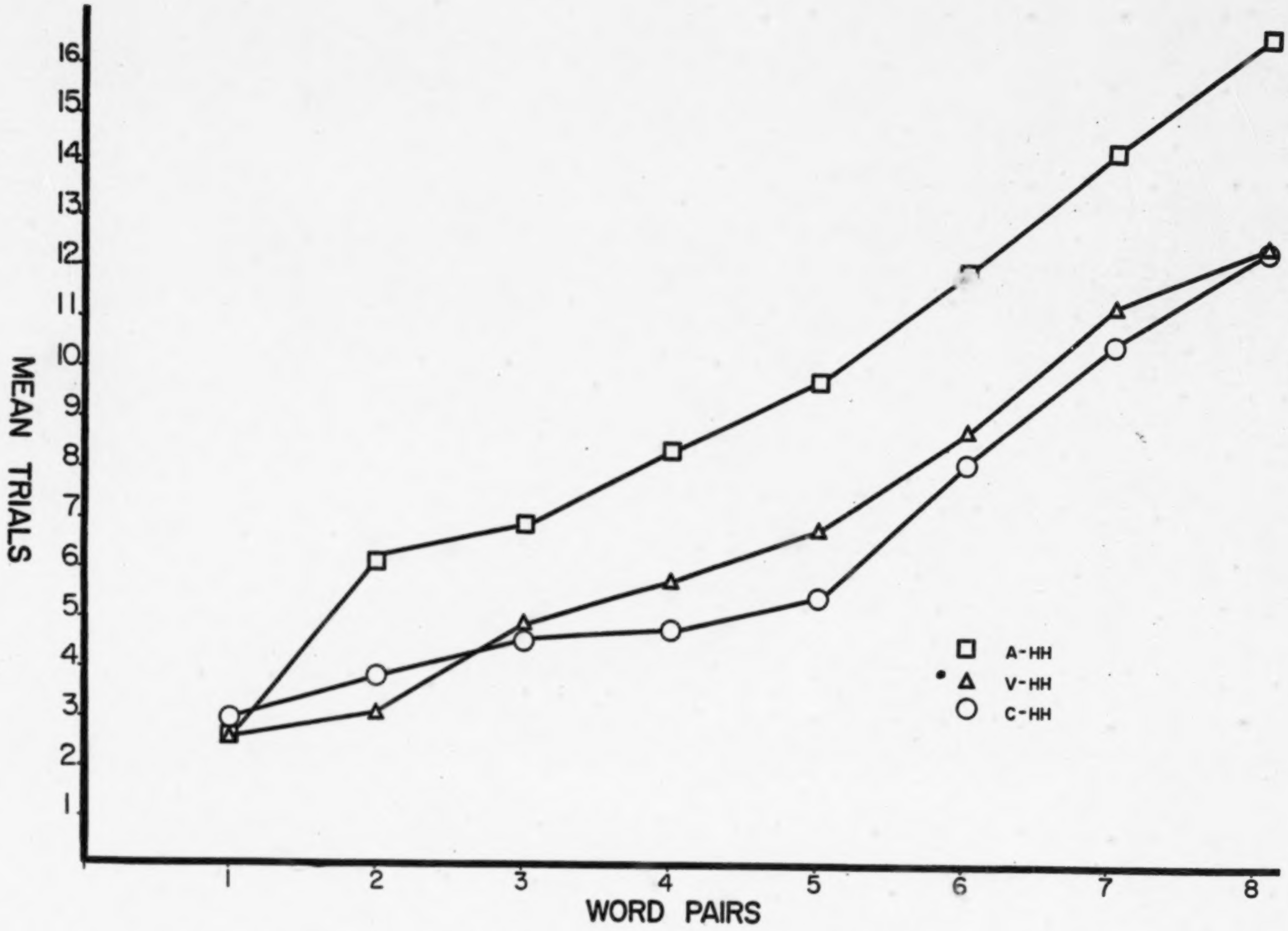

Fig. 4.1 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 16-30 db loss group.

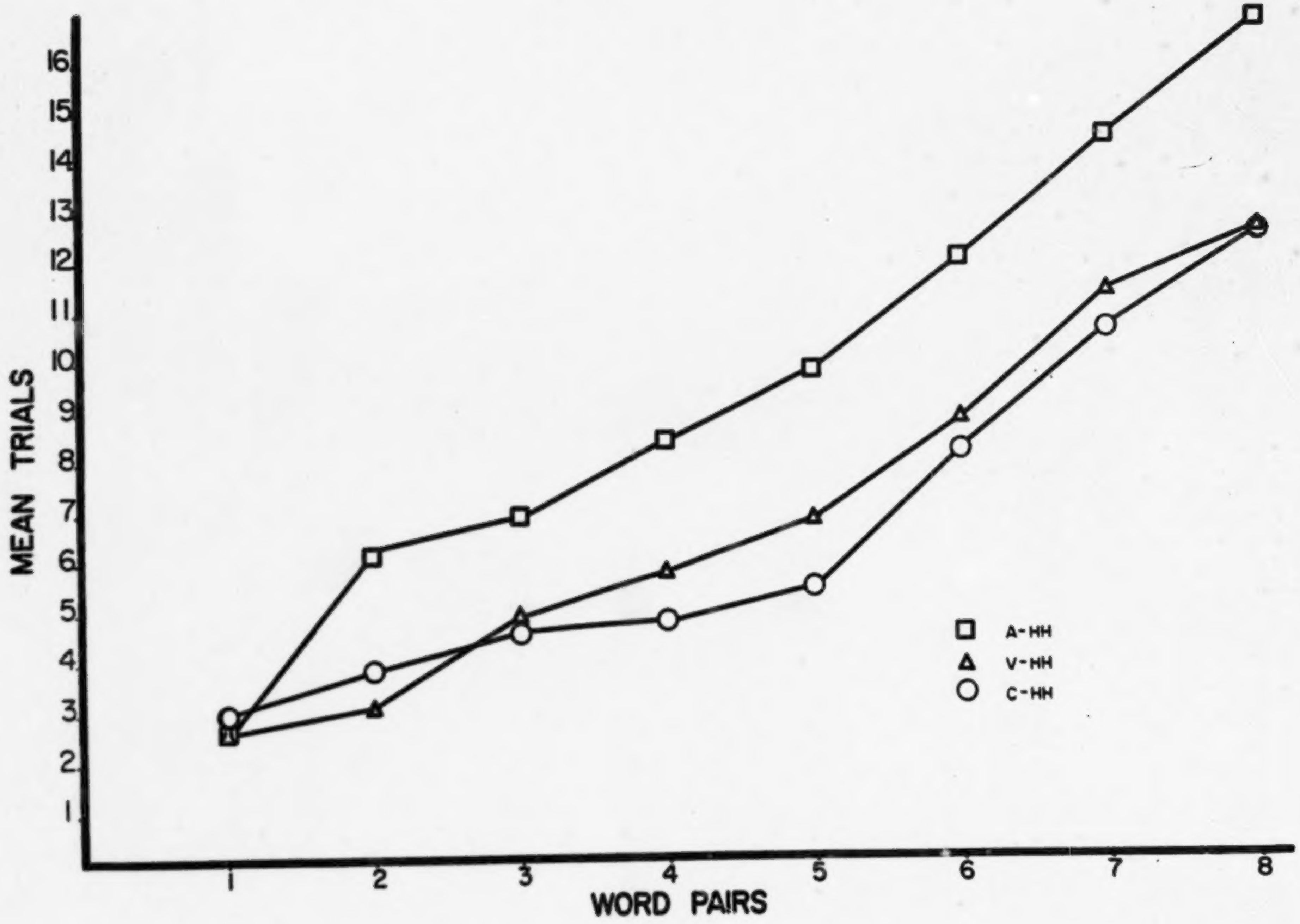

Fig. 4.2 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 31-45 db loss group.

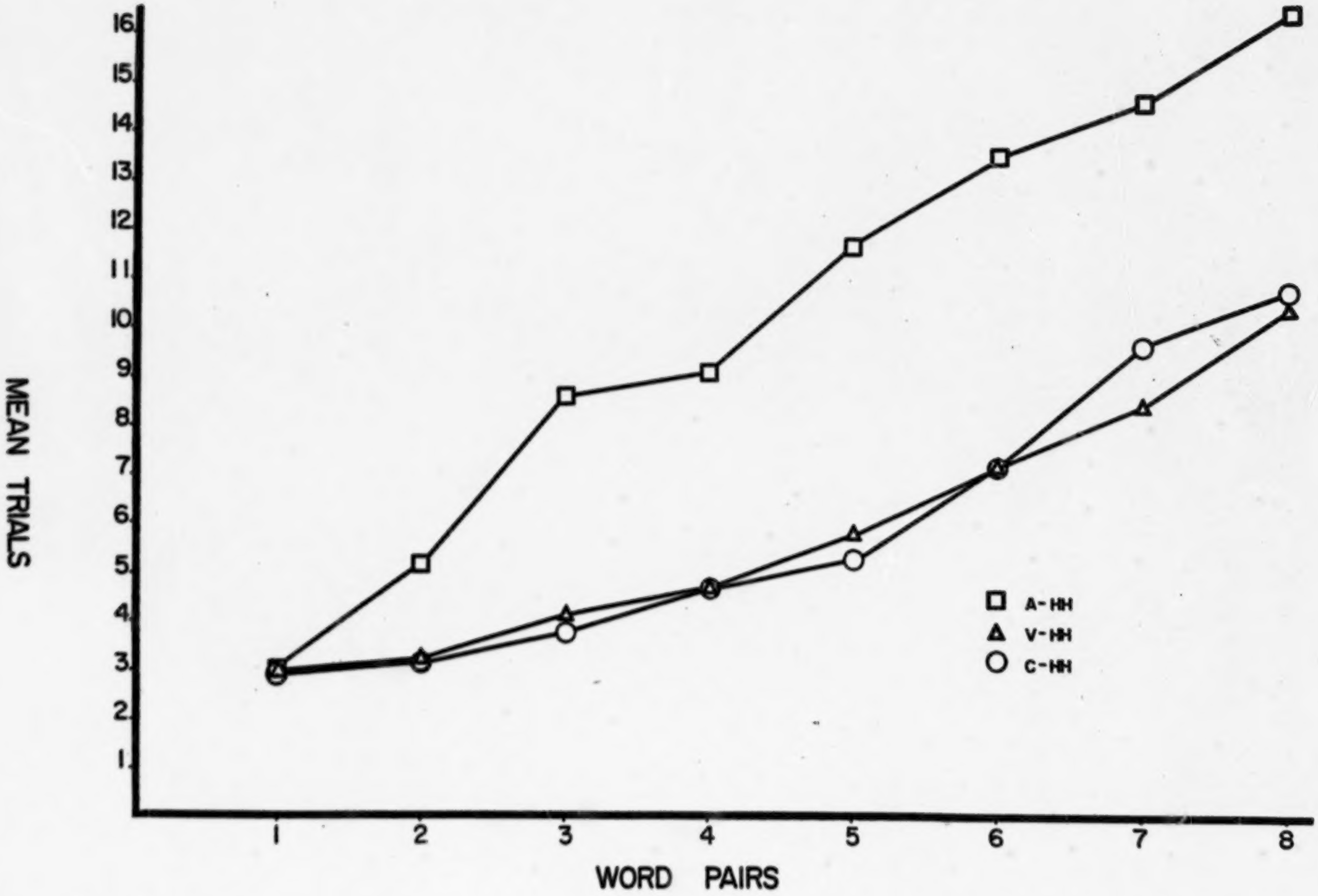

Fig 4.3 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 46-60 db loss group.

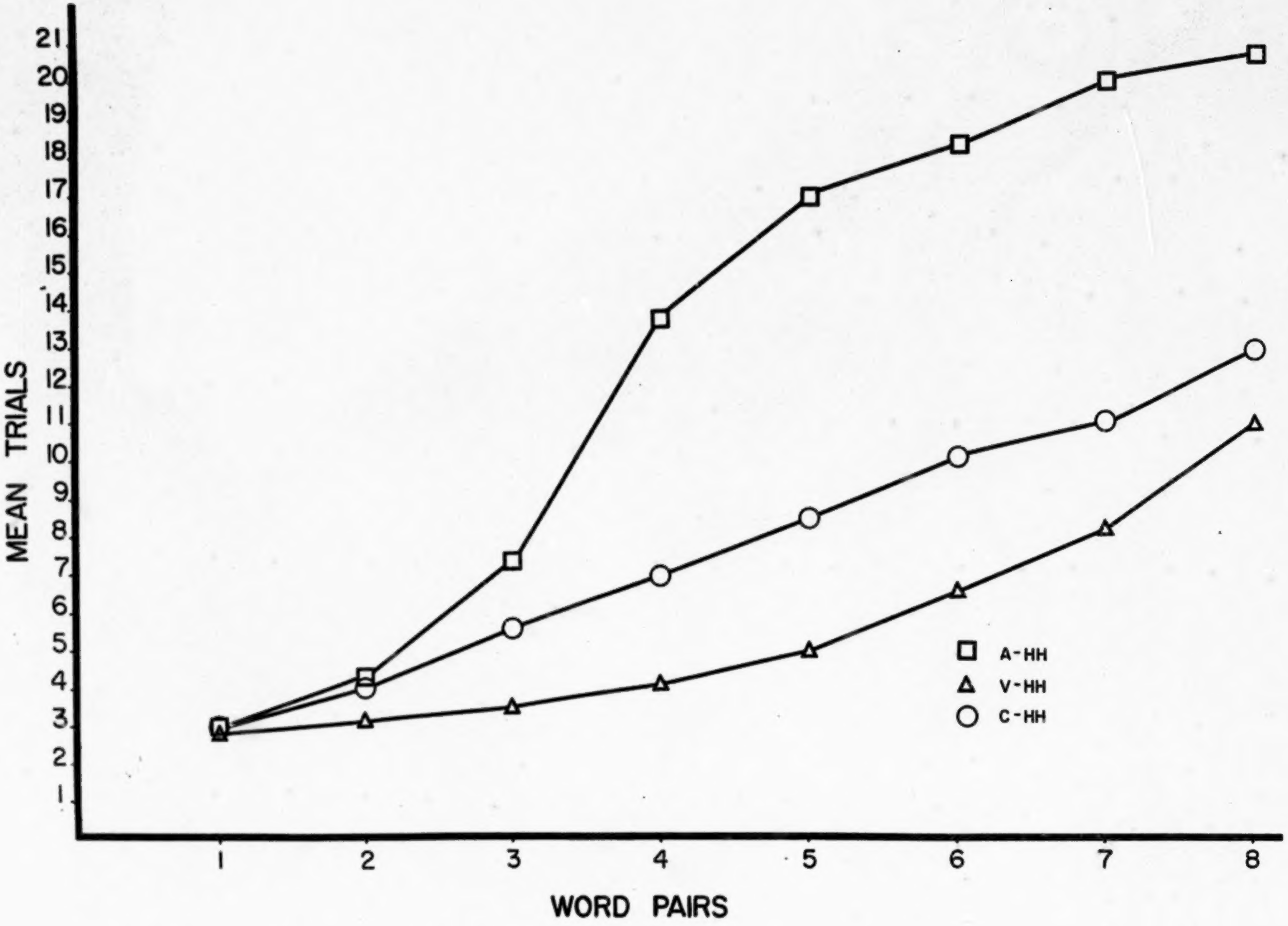

Fig. 4.4 Mean trials for the eight successive word pairs; Sub-conditions A, V, and C in the 61-75 db loss group.

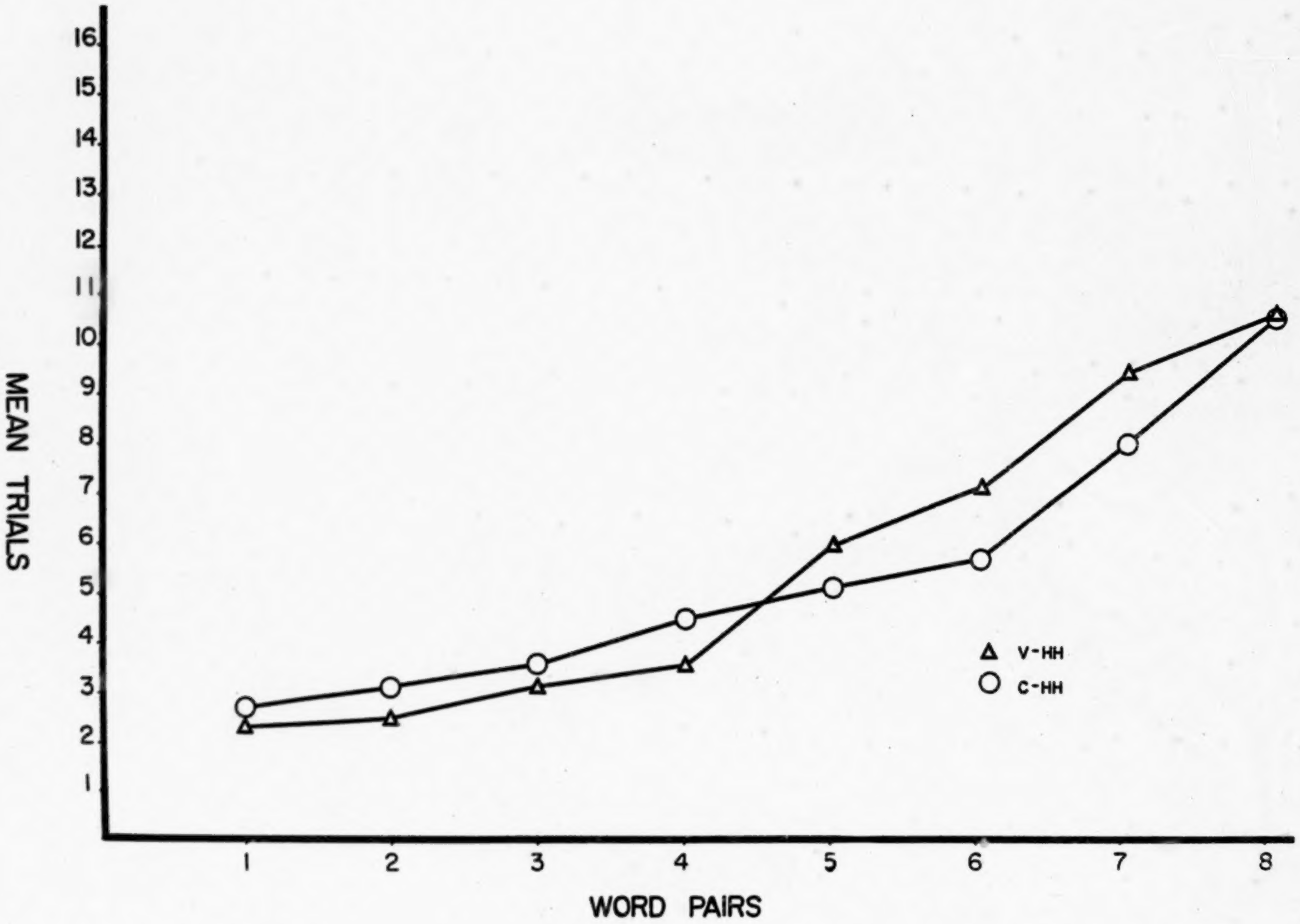

Fig. 4.5 Mean trials for the eight successive word pairs; Sub-conditions V and C in the 76-90 db loss group.

TABLE 4.6.--Summary of analysis of the three methods of presentation.

Source	df	MS	F
Visual Groups	4	7.58	.40
Error (w)	45	19.03	
Total	49		
Auditory Groups	2	35.44	.63
Error (w)	27	56.02	
Total	29		
Combined Groups	4	14.33	.36
Error (w)	45	39.10	
Total	49		

TABLE 4.7.--Summary of the analysis of variance on the V and C Conditions and the 5 hearing-loss groups.

Source	df	MS	F
Conditions (C)	1	18.49	.64
Hearing-Loss Groups (G)	4	17.22	.59
C x G	4	6.56	.22
Error (w)	90	29.08	
Total	99		

Scores were obtained on all subjects in the first 3 hearing-loss groups (16-30, 31-45, and 46-60 db) under all 3 conditions. These scores were analyzed in a 3 x 3 analysis of variance (factorial design), which is summarized in Table 4.8.

TABLE 4.8.--Summary of the analysis of variance on trials to criterion for Conditions A, V, C and the 3 hearing-loss groups.

Source	df	MS	F
Conditions (C)	2	194.73	5.58^{**}
Hearing-Loss Groups (G)	2	19.30	.55
C x G	4	33.18	.95
Error (w)	81	34.90	
Total	89		

$^{**}P = .01$

The analysis yielded a significant F based upon the "between conditions" Mean Square. There was no significant difference between hearing-loss groups, nor was the interaction term significant. The means for the Conditions were: A = 16.1, V = 11.2, and C = 12.1. The Duncan Test indicated that the subjects in Condition A required significantly more trials to learn the eight word-pairs than subjects in Conditions V and C. Conditions V and C did not differ significantly from each other.

c. Comparison with Normals. One of the reasons for gathering extensive data on normal children was to provide a reference from which to evaluate the hard-of-hearing. From the analysis just discussed, it is apparent that the groups of hard-of-hearing children differ from each other only in Condition A. Therefore, the total means of the 5 groups represent the performance of the hard-of-hearing children very well, except for the auditory condition. For the normal-hearing children there were significant differences among the grades; the performances, on the average, tended to improve throughout the grades. Inspection of the data revealed that the scores from the hard-of-hearing were better than the third grade normals, but not as good as the fourth grade on the V and C Conditions (Table 4.9).

TABLE 4.9.--Mean trials to criterion on Conditions A, V, and C, for hard-of-hearing subjects and third and fourth grade normal-hearing subjects.

Groups	Conditions		
	A	V	C
Hard-of-hearing	18.1	11.6	11.8
Third Grade Normal	16.4	15.1	16.1
Fourth Grade Normal	10.7	9.0	9.9

Two general conclusions are appropriate from the data:

1. The performances of the hard-of-hearing children, whose age range was from 8 to 15, were about 3rd - 4th grade level of normal-hearing subjects on the task utilized.
2. Condition A was poorest for all hearing-loss groups, and was also poorer for the hard-of-hearing when compared to normal groups.

d. Retention. The scores obtained from the hard-of-hearing and normal children were not directly comparable. Mainly, the differences come from the fact that the hard-of-hearing children learned 3 eight word-pair lists as opposed to a single eight word-pair list learned by normal children. A further problem arose in obtaining retention scores on children in the 16-30, 31-45, and 46-60 db hearing-loss groups due to the fact that the children were located in widely separated areas. It was possible to obtain retention scores on only about 35% of these three groups.

The retention scores were available for all subjects in the 61-75 and 76-90 db groups. The means for these two groups were: V = 2.3 and 4.3, and C = 4.2 and 4.1 respectively. The means of the pooled data for the other three groups were: A = 2.1, V = 3.5, and C = 3.5. As described under Experiment III, the normal subjects were able to recall about 4.7 correct responses a week later. In view of the differences in the learning and retention procedures, the results with the hard-of-hearing were not considered to be appreciably poorer.

f. Discussion. There were several significant findings that emerged from the learning studies conducted with the hard-of-hearing children. First it had been hypothesized that the over all performances of the hard-of-hearing and normal-hearing groups would be approximately equal. When the total scores of both groups were averaged the data supported the hypothesis. However, such a statement does not adequately represent the data. There were significant differences among the grades for all conditions. Therefore, it was not appropriate to pool the scores across grades. However, there were no significant differences among the hearing-loss groups on any condition except auditory even though the age and grade classifications were different among the hearing-loss groups. Because the hearing-loss population was limited, it was not possible to take age and grade into account. In spite of this, the indication is that the average performance of the hard-of-hearing falls at a level between the normal third and fourth grade. However, a grades by hearing loss study should be carried out before the inference should be given serious support.

It was also assumed that the performances of the hard-of-hearing groups would be poorest on Condition A. However, the relative performance on Condition A was poorer than had been expected. The children in the 16-30 and 31-45 db hearing-loss groups were all in public schools and considered up-to-grade in achievement. Most of the children in the 16-30 db loss group did not wear hearing aids, because it had been assumed they did not need them. The majority of the children in the 31-45 db group wore hearing aids and had normal discrimination for speech on PB-lists. In spite of supposedly good hearing for speech, the performance of these children on Condition A was significantly below the performances on Conditions V and C. Furthermore, many more children in the severe hearing-loss groups were unable to learn the lists than had been anticipated, even though all of the children in these latter groups were hearing aid wearers or had had auditory training. In general, these data suggest that conventional measures of auditory discrimination are not good indicators of ability to use audition in a simple learning task.

A finding in the present study confirms a suggestion advanced in the prospectus of the project, namely, that the performance of hard-of-hearing children under Condition C would not be superior to performance under Condition V. However, on the basis of these findings, no direct inferences regarding auditory training appear to be warranted.

The data on retention for the hard-of-hearing do not lend themselves to extensive interpretation. However, the results from the normal subjects suggest a probable inference. It will be recalled that retention was about equal among conditions and grades even though the trials required to learn the word-pairs had been different. There is no reason to suspect that this finding would not also hold for the hard-of-hearing groups. Therefore, retention may be expected to be as good for the A Condition even though the number of trials required to learn the list may be greater. The data are interpreted as supporting this view. Further research is needed to determine if this finding could be generalized to teaching the hard-of-hearing.

E. Experiment V. Effect of Stimulus and Response "Meaningfulness."

1. Introduction and Hypothesis. The studies reported thus far in the project were concerned with relationships among methods of sensory presentation when the variable of word-list differences was controlled. It seemed conceivable that different relationships might appear among the three methods of sensory presentation when the list characteristics were varied systematically.

The facilitating effect of meaningfulness on the learning of verbal material has been well demonstrated through experimental investigation. Meaningfulness has typically been defined in terms of the number of associations that a particular word elicits, the greater the number of associations the more meaningful the word (Noble 1952). Meaningfulness of nonsense syllables has also been defined in terms of associative values established by Glaze (1928), and Hull (1933). No one is known to have tried to relate this variable to the method of presentation.

In the attempts to define the conditions under which meaningfulness of material facilitates verbal learning, several studies have been reported in which the relationship of meaningfulness and position of a word in a word pair has been investigated. Although the evidence is not conclusive on this matter, the majority of studies tend to support the view that meaningfulness of the response member of a word pair exhibits the greatest effect on verbal learning. Noble and McNeely (1957); Cieutat, Stockwell, and Noble (1958); Sheffield (1946); and Hunt (1959) make such reports while Kimble and Dufort (1955) report the opposite.

The studies cited were performed using a visual method of presentation. The present study was concerned with the relative effects of meaningfulness of the stimulus and response members of the word pairs when the method of presentation was auditory, visual or combined. Another important way in which the present study differed from others is in the definition of meaningfulness. Meaningfulness in the present study was defined according to grammatical usage. For example, some words may be used as nouns (tree, song, etc.) while other words may be used both as nouns and and verbs (ship, sign, etc.). According to this criterion, words used as nouns only were considered to have "single meaning" (S) while words used as nouns and verbs were classified as having "double meaning" (D).

Three hypotheses were advanced for the present study. First, it was predicted that the meaningfulness of the response member of a word pair would facilitate verbal learning while meaningfulness of the stimulus member would have relatively little effect. Second, it was predicted that the method of sensory presentation would interact more with the meaningfulness of the response word than with the meaningfulness of the stimulus word. While the first prediction was suggested from the evidence cited above, the second prediction seemed warranted in terms of Bugelski's proposal (1957), namely, that the stimulus member serves only as a cue which occasions the emmission of the response in paired-associate learning. Thus, the method by which the stimulus word is presented seems of little consequence provided the subject is aware of its presence. Therefore, if meaningfulness of either the stimulus or response is to interact with the method of presentation, the response member is more likely to interact. Third, it was predicted that when the list variable was ignored, the results from the A, V, and C methods of presentation would not differ from each other

2. Plan of the Experiment. Three main experimental variables were investigated in the present study: (1) stimulus meaningfulness, single (S)

or double (D); (2) response meaningfulness, single (S) or double (D); and (3) three methods of presentation, A, V, and C. Twelve experimental groups were utilized to test these effects. The lists were varied in 4 ways using either single or double meaning words as the stimulus and response members; i.e., S-S, S-D, D-D, and D-S. Each list was presented by the A, V, and C methods. Four paired-associate lists were used, each consisting of 10 word pairs. All words used had four letters, were selected for frequency of occurence in terms of everyday usage as "AA" by Thorndike and Lorge (1944), and were simple words of third grade difficulty or less. Words used as double meaning (D) words were those classified by grammatical usage as being both a noun and a verb, while the single meaning (S) words were used only as nouns. The lists were presented with the Patterson and electronic memory drums and the two Ampex tape recorders.

In the preparation of the lists, twenty (S) words and twenty (D) words which met the specified criteria were chosen. The S-S list was constructed by choosing ten of the (S) words at random for stimulus words; the remaining ten were used as response words. List D-D was constructed in the same manner using the (D) words. List S-D utilized the ten (S) stimulus words from list S-S and the ten (D) response words from list D-D. List D-S was prepared in a like manner. Precautions were taken in the pairing of words on each list to minimize associative meanings between the two words and to randomize the order of occurence of word pairs for each trial. Appendix B contains the four word lists.

One hundred and twenty 5th and 6th grade children selected at random from a Detroit Public School served as Ss. All Ss were naive with regard to verbal-learning experiments. Ten Ss were assigned in random order to each of the twelve experimental groups and no S served in more than one group.

Learning was by the anticipation method on all but the first two list presentations. These two presentations were to acquaint the Ss with the words and to serve as practice on the task. All Ss received 16 additional trials during which the correct responses were recorded on a score sheet by the E. Presentation of all ten word pairs constituted one trial.

Three Es were used and their effects on the experimental conditions were counterbalanced. Furthermore, the effect of time (A.M. vs. P.M.) was counterbalanced in each of the twelve experimental groups.

3. Findings. The mean number of correct responses for each of the twelve groups is presented in Table 5.1. The row means represent the grand means for each list ignoring method of presentation. The column means represent the grand means for each method of presentation ignoring the various lists.

TABLE 5.1.--Mean correct responses for twelve experimental groups in Experiment V.

Lists	Method of Presentation			Row Mean
	A	V	C	
S-S	91.0	94.2	74.5	86.6
D-S	77.4	85.0	69.7	77.4
D-D	72.8	73.0	76.2	74.0
S-D	71.6	64.8	76.0	70.8
Col. Mean	78.2	79.2	74.1	

A 2 x 2 x 3 x 4 analysis of variance (Lindquist, 1953) was performed in which stimulus meaningfulness, response meaningfulness, method of presentation, and trials were the main effects. For this analysis the 16 test trials were grouped by blocks of 4, thus giving 4 trials to be analyzed.

A summary of the analysis is presented in Table 5.2. As seen in the table, only the trials main effect and the first order interaction of method of presentation with trials (C x T) reached an acceptable level of significance.

TABLE 5.2.--Summary of analysis of stimulus, response, and method of presentation variables.

Source	df	MS	F
Between Ss	119		
Stimulus (S)	1	67.49	.23
Response (R)	1	686.40	2.34
Presentation (C)	2	74.06	.25
S x R	1	288.31	.98
S x C	2	21.23	.07
R x C	2	392.42	1.34
S x R x C	2	26.72	.09
Error (b)	108	293.29	
Within Ss	360		
Trials (T)	3	11,076.89	427.02***
S x T	3	8.12	.31
R x T	3	59.37	2.29
C x T	6	82.67	3.19**
S x R x T	3	54.26	2.09
S x C x T	6	7.82	.30
R x C x T	6	5.54	.21
S x R x C x T	6	36.38	1.40
Error (w)	324	25.94	
Total	479		

***P = .001

**P = .01

The significance of the differences among trials was to be expected and merely indicated improvement with continuation of the task. The conditions by trials interaction points to differences among A, V, and C Conditions related to success on the various blocks of trials suggesting that the rate of learning varied among conditions. The relation of conditions to trials is shown in Figure 5.1. It is evident from inspection of the curves that the C Condition deviated from the parallel relationship of the A and V Conditions.

Neither the stimulus nor the response main effects were significant, but the relative variance contributed by the variables was of interest. The Mean Square term for the response effect of 686.40 differed from the stimulus effect MS of 67.49 by a ratio of about 10 to 1. Although no statistical reliability was attributed to this ratio, it was in the predicted direction. A comparison of the Mean Squares for the response by condition (392.42) interaction and the stimulus by condition (21.23) interaction yielded a ratio about 19 to 1. This too was in the predicted direction indicating response dominance.

Inasmuch as the R x C (response by condition) term was the only intersubject interaction yielding an F greater than 1.00 and since this interaction was of particular interest in the present study, three post mortem simple 1 x 2 analyses were performed on the response meaningfulness variable for the A, V, and C methods of material presentation. Obviously such analyses capitalize on chance differences; the reason for doing them was for purposes of planning further research. Neither the auditory nor combined methods of presentation revealed differences between the single and double meaning response members. Only in the visual condition did the number of correct responses differ significantly ($P = .05$) with the single response groups

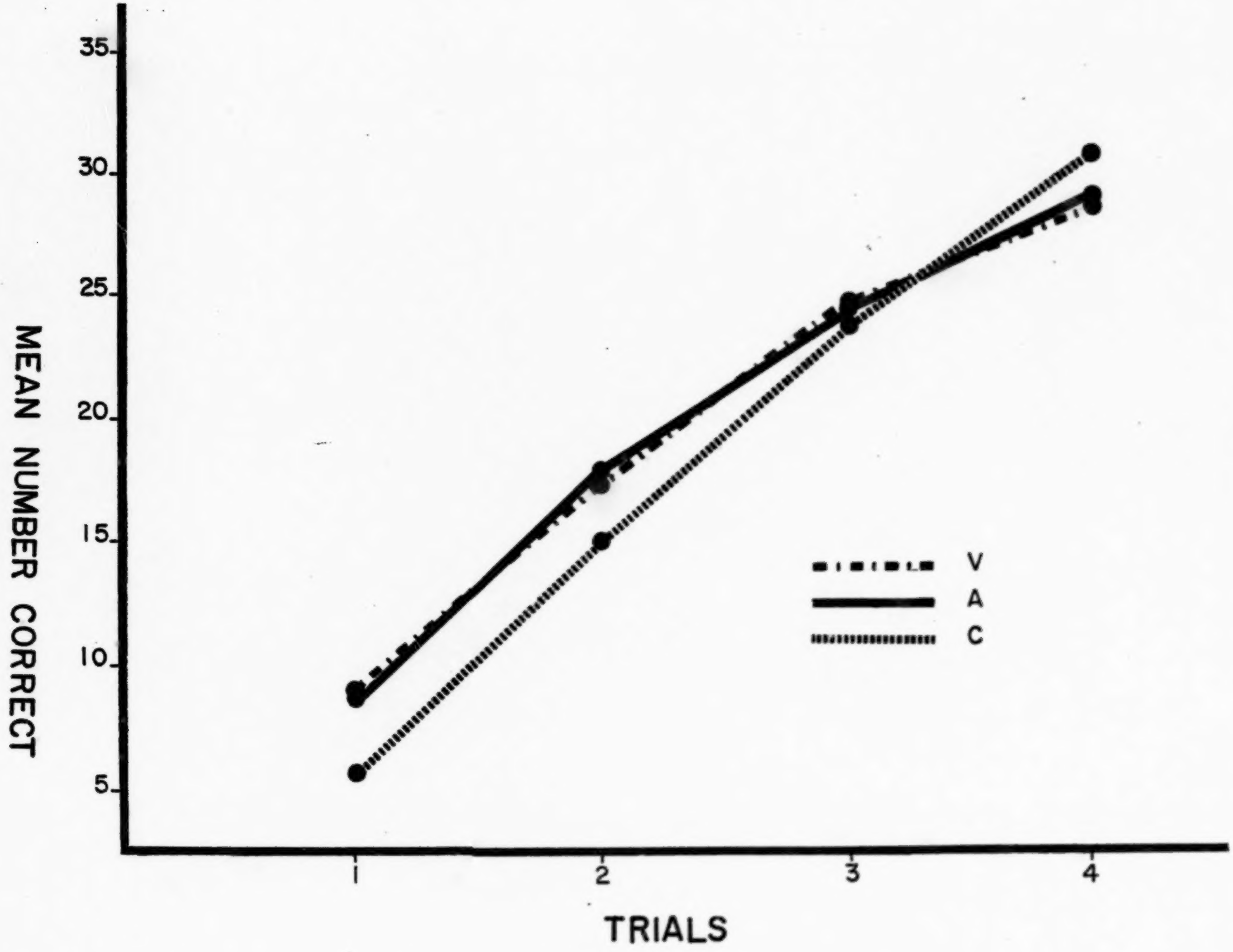

Fig. 5.1 Mean number of correct responses per trial for the A, V, and C methods of presentation.

attaining more correct responses than double meaning response groups ($\bar{X}$ S response = 89.6, $\bar{X}$ D response = 68.9). On the basis of these three analyses, it appears that differential performance relative to meaningfulness of the response words occurred only when the material was presented visually.

4. Discussion. Three major hypotheses were tested in the present study:

a) Meaningfulness of the response member of a word pair would facilitate verbal learning while meaningfulness of the stimulus member would have relatively little effect.

b) Method of presentation and meaningfulness of the response word would interact more than method of presentation and meaningfulness of the stimulus word.

c) When list variables were not considered, the A, V, and C methods of presentation would yield equivalent results.

On the basis of the results from this study, the first two hypotheses were not accepted. However, with regard to the relative importance of the response versus stimulus words, the results were in the predicted direction. Specifically, the relative variance contribution of the stimulus and response members were compared on the main effects (stimulus and response), the S x C (stimulus by method of presentation) vs. R x C (response by method of presentation), and the S x T (stimulus by trials) vs. R x T (response by trials) interactions. The ratios of response to stimulus variance were 10 to 1, 19 to 1, and 7 to 1 respectively for these comparisons. Furthermore, no interaction term in which S and R were both involved reached a significant F value so there was obviously no interacting factor complicating the relationship of the two variables.

Even though no statistical reliability is placed on these ratios, it is of interest that each was in the predicted direction. The possibility exists that in future studies better control of the inter-subject differences would reduce inter-subject variability which in turn would reduce the appropriate error term. Proper regard for this factor could lead to more significant non-correlated F values.

Inasmuch as the response words appear to be more related to facilitative effects on verbal learning than the stimulus words, it is of interest to note the differences in mean number of correct responses for (D) response lists vs. (S) response lists. As noted from the row means in Table 5.1, the lists in which the response words were singular in meaning had a mean of 82.0 correct responses as compared with a mean of 72.4 for the double meaning response. The mean for the (S) stimulus words was 78.7 as compared with a mean of 75.7 for the (D) stimulus words.

The fact that the groups with (S) response words performed relatively better than groups with (D) response words probably should not be considered surprising. As mentioned, meaningfulness has been defined in previous studies as an intrinsic relation between the word and the subject, that is, meaningfulness is based upon subject's performance relative to a given word. In the present study, meaningfulness is an extrinsic relation based upon grammatical usage and not upon the subject's performance. It is therefore possible, that the words used in the present study as (S) words had greater meaning to the subjects than words in the (D) category, if measured in terms of associative value.

Consideration of the column means in Table 5.1 indicated that when differences in word lists were ignored, the performance of the subjects with the auditory and visual methods of presentation was practically identical while the combined method was slightly poorer. These findings are interpreted as supporting the third hypothesis. However, when methods of presentation were compared between different lists, notable but statistically unreliable differences emerged. For example, the A method for list S-S had a mean of 91.0 correct responses compared to 64.8 for the V method on list S-D; or the V method on list S-S had a mean of 94.2 while the A method for list D-D mean was only 72.8. Furthermore, a list comparison within one method also showed sizeable differences in mean correct responses.

The results of the present study suggest that additional research on the general problem addressed here would be of value. Specifically, it appears that differences in method of presentation could be related to systematic differences in the nature of the word lists. Furthermore, the relative variance contribution of stimulus and response words needs to be investigated along with their relationship to meaningfulness as defined by grammatical usage.

F. Experiment VI. Effect of Pronunciation.

1. Introduction and Hypothesis. This experiment was one of three pilot studies conducted in an attempt to search for additional information concerning the possible effects of various methods of presentation on the learning of verbal material. The other two studies are considered separately and reported as Experiments VII and VIII.

Pronunciation as defined here means speaking the words aloud as contrasted to subvocal pronunciation. Relevant studies suggested that active participation in a task lead to superior acquisition compared with passive observation of the task. More specific to verbal learning, Noble (1952) has suggested that varying amounts of pronunciation of the words in a paired-associate task may be an important variable in the learning of the word pairs. Such a suggestion may have important implications for education of the deaf.

The hypothesis advanced in the present study was that as the number of pronunciations of the nonsense syllables increased, the number of correctly anticipated responses on the test task would increase. However, there would be a limit to the facilitating effect of pronunciation.

2. Plan of the Experiment. Three separate groups of 10 Ss were each given six preliminary trials under one of three levels of pronunciation: (1) observe the syllable pairs the first four trials and pronounce them on the last two trials; (2) observe the pairs on the first two trials and pronounce them on the last four; and (3) pronounce the pairs on all six preliminary trials. Each group then received six trials of standard paired-associate learning, All presentations were made with the Patterson memory drum.

The test list consisted of 10 pairs of four-letter nonsense syllables constructed so that the syllables were pronounceable but were not readily associated visually or auditorily with any meaningful word. The 20 nonsense syllables were then formed into pairs with minimal intra-pair associative value as judged by the experimenters. The list is given in Appendix B.

Thirty 10th grade pupils, naive to the verbal-learning task, served as subjects. Ten subjects were assigned at random to each of the three experimental groups. Prior to the preliminary trials each subject was shown the 20 nonsense syllables and a common pronunciation was imposed.

A trial consisted of one presentation of the list of 10 syllable pairs. Three random orders of syllable presentation were utilized. Learning was by the anticipation method on the test trials.

3. Findings. One of the characteristics of the results was the variability of performance among the subjects for each condition; frequency distributions were not normal, and Bartlett's Test was significant. These findings made the use of the mean and standard deviation inappropriate. Therefore, the median was used to describe the average performance, and non-

parametric statistics were employed from which to draw inferences.

The median numbers of correct responses for the groups were 10.0, 18.5, and 14.5 for the 2, 4, and 6 pronunciation trial-groups respectively. The Mann-Whitney U analysis was performed on the sample medians. The difference between the medians of the 2 and 4 trial pronunciation groups was significant (P = .02), the other differences were not significant.

4. Discussion. The median numbers of correct responses were interpreted as lending support to the hypothesis advanced. As pronunciation during the preliminary trials increased from 20 pairs to 40 pairs, the median number of correct responses during test trials increased significantly from 10.0 to 19.5. The difference between 40 and 60 pronunciations was not significant, thus suggesting that the limit of improvement was reached. In fact, the scores from the group which pronounced for six trials were poorer than the group which pronounced for four trials.

As stated in the introduction, the experiment was designed as a pilot study. However, the results were promising and suggest further study. It is possible that the differences in performance were chiefly due to an increase in attention. Inasmuch as the subject had to pronounce the syllables it was necessary for him to attend to the task to a sufficient degree to pronounce the nonsense syllables correctly. On the observation trials, the subject was not committed to an overt response and thus could have assumed an attitude of less attention.

Another explanation of the results was that the auditory feedback produced by pronunciation was the critical variable. If this were true, it would have important implications for hard-of-hearing and deaf children. It is planned to gather additional data concerning the effect of pronunciation on verbal learning.

G. Experiment VII. Effect of Change in Stimulus-Response Pairing.

1. Introduction and Hypothesis. Trials to criterion and total correct responses were two of the measures of learning used in this project. With the measure of trials to criterion, Experiment I revealed that the group under the visual condition required significantly fewer trials to learn a four-pair word list than the group under the auditory condition. Experiment V yielded results showing no significant differences between the two methods of presentation when the measure was the number of correct responses for a sixteen trial block. However, subjects attained more correct responses (79.2 to 78.2) with the visual method than with the auditory method.

The present experiment represented a further study of the relative efficiency of the auditory and visual methods of presentation. Specifically, the study concerned possible effects on performance of changing the stimulus-response pairings during the learning task. Performances of subjects learning the lists with the auditory and visual methods of presentation were to be compared. It was predicted that subjects in the visual condition would make more correct responses on the first list presented but that the performance of the visual group would be inferior to that of the auditory group when the stimulus and response members of the word pairs were changed.

2. Plan of the Experiment. Two methods of presenting the word lists (visual and auditory) and two blocks of six trials each on two separate pairings of the 5 stimulus and response words constituted the basic design of this study. The two lists were counter-balanced between two blocks of trials for both the auditory and visual methods.

Five word pairs were chosen at random from a 10 word list (D-D) used in Experiment V. These five pairs comprised one of the lists. The second list was formed by making new pairs using the same five stimulus and response words. No pairing appeared on both lists. The words were presented with the Patterson memory drum and the Ampex tape recorder.

Each subject was assigned at random to one of the two experimental Conditions, A or V, and given one presentation of the word pairs to acquaint him with the pairs. Each S was then given six trials to learn the five word pairs. For each trial, the word pairs were presented in a separate random order. Following the sixth trial the S was instructed to learn a new list of words and was then given an additional six trials to learn the new pairings. Learning was by the anticipation method, and correct responses were recorded on standard response sheets by E.

3. Findings. The mean numbers of correct responses for the two six-trial blocks are shown for both conditions in Table 7.1. As will be noted from the table, subjects in Condition V performed better than subjects in Condition A on the first six trials and poorer on the second six.

TABLE 7.1.--Mean correct responses for visual and auditory conditions on the two pairings of the word lists.

Condition	Trials		Mean difference
	First six	Second six	
Visual	18.1	10.5	-7.6
Auditory	12.1	14.9	+2.8

Two separate lists were presented in a counterbalanced order for both conditions. The mean numbers of correct responses for each list on the first six-trial block are shown in Table 7.2 for the A and V Conditions. Analysis of the data revealed no significant differences between lists 1 and 2 in either condition. Therefore, both lists within a condition were considered to be of equivalent difficulty.

TABLE 7.2.--Mean numbers of correct responses on two lists over the first six trials for Conditions A and V.

Condition	n	List 1	n	List 2
A	5	12.4	5	11.8
V	5	17.0	5	19.2

Three t-tests between the scores of the auditory and visual conditions were performed; one for the first six trials, one for the second six, and one for the mean difference between the first and second blocks of trials. The t-test performed on the scores of the two groups from the first six trials yielded a t = 2.13 (df 18), which was significant at the 5% level. The t-value of 1.51 (df 18) for the second block of six trials failed to reach significance. The relative difference in performance between the first and second blocks of trials for the visual and auditory groups was of special interest. The t-test performed on the difference scores yielded a value of 28.34 which was well beyond the 1% level of significance.

4. Discussion. The data presented were interpreted as generally supporting the hypothesis advanced concerning the relative performance of the visual and auditory groups. On the first block of six trials, the visual group made more correct responses than the auditory group, while on the second block they gave fewer correct responses.

The superior performance of the subjects in the visual condition on the first block of trials tends to support the findings from Experiment I; namely, that on a short word list the performance of subjects under the visual condition was superior to performance of subjects under the auditory condition. These two sets of results are pointed out as two exceptions to the general inference that Conditions A and V were equal in most normal-hearing subjects.

Performance of the two groups on the second task indicated that it was relatively more difficult for the visual group to extinguish the learned responses from the first task and to learn the new stimulus-response pairs. This was probably due to the fact that subjects in Condition V learned some of the word pairs early in the initial task and thus experienced more reinforced responses than subjects in Condition A. Therefore, greater associative strength was built up between the pairs, and these pairs were the most resistant to extinction.

While the results were in the predicted direction, they must be interpreted with caution. First, the small sample limits the generality of the findings. Second, the study was intended as a pilot study and thus was only intended to give indications for further research. Third, the fact that the visual group performed significantly better on the first six trials confounds somewhat the analysis of performances on the second six trials.

One trend noted in the project was that performances on short word lists tended to favor the visual method of presentation. However, performances on the longer lists failed to reveal significant differences among the methods. This suggests that the relative superiority of a method of presentation may need to be related to a specific task before any conclusions of the relative superiority of the auditory or visual conditions of presentation can be drawn.

H. Experiment VIII. Effect of Group Presentation

1. Introduction. One of the major problems in educational and psychological research is the estimation of population parameters from data gathered on random samples from specified populations. In a study of verbal learning in children, one is consistently impressed with the inter-subject variability of performance on learning tasks. One way in which the reliability of statistical estimates of population parameters can be increased is through

the use of large samples. Group testing represents a procedure in which large sample data can be obtained.

The purpose of the present experiment was to investigate the feasibility of administering the auditory and visual methods of presentation to subjects in groups. If such a procedure proved to be satisfactory, it could provide more stable estimates of population parameters as well as reduce the cost per unit of observation.

a. Plan of the Experiment. Two grade levels (5th and 6th) and two methods of presentation (A and V) were the main experimental variables. The order of the conditions was counterbalanced with respect to grades.

A Bell & Howell automatic slide projector, Model 750, using 2" x 2" slides was procured for the visual presentation. A 4 second interval was used for the presentation of the stimulus word, the intra-pair interval, the response word, and the inter-pair interval. Thus, the total time required to present one word pair was 16 seconds. An Ampex tape recorder with an attached loudspeaker was used for the auditory condition. The time intervals were the same as those used in the visual condition.

List #4 was used for all 4 groups. The plan called for ten learning trials and each subject was given an answer pad (4" x 6") containing 10 pages with 8 blanks each, one page per test trial.

Seventy-two 5th grade and sixty-eight 6th grade subjects were presented the 8 word-pair list either visually or auditorily. One-half of the subjects in each grade were given the auditory condition and one-half the visual condition. Prior to the first test trial, the experimenter presented each of the 8 word pairs to familiarize the subjects with the list. The subjects' task was to learn the word pairs and to write the appropriate response word in the space provided before the word appeared on the screen or was heard over the loudspeaker. After each trial the subjects started a new page so that the preceding responses were not in view. A trial consisted of one complete presentation of the 8 word pairs.

b. Findings. Table 8.1 presents the mean numbers of correct responses per condition for the 10 trials.

TABLE 8.1.--Mean numbers of correct responses as a function of grades and method of presentation.

Grade	Auditory			Visual		
	n	Mean	S.D	n	Mean	S.D.
5	36	44.8	14.0	36	51.0	14.9
6	34	59.5	13.2	34	58.2	13.6

The data were analyzed by the t test. Neither grade showed significant differences between the A and V Conditions (5th, t = 1.81; 6th, t = .38). The mean differences between grades were significant for both conditions. For the auditory condition, t = 4.52, (P = .01), and for the visual condition, t = 2.13, (P = .05). As one would expect from the standard deviations, the Bartlett's test confirmed the likelihood of random sampling from a single population.

In order to allow a comparison with earlier data, an analysis was made of the trials on which each subject first correctly anticipated all on the 8 response words. The means by groups are presented in Table 8.2.

TABLE 8.2.--Mean trials to criterion for 5th and 6th grade subjects for the auditory and visual methods.

Grade	Auditory		Visual	
	n	Mean	n	Mean
5	25	7.6	25	6.8
6	29	6.6	29	5.1

Not all subjects learned the list in ten trials. However, learning clearly takes fewer trials with this group testing procedure. In Experiment III, the data showed that, on the average, 11.6 trials were required for Sub-condition A - A and 10.2 for Sub-condition V - V with 7th grade children. Assuming normal distribution, only 50% of the seventh grade children had learned List #4 by the 10th trial. In the group situation, approximately 70% of the 5th and 6th grade groups had learned the same list by the 7th trial. Probably the most likely reason for the reduction in the number of trials required to learn the list in the group procedure was the increased time between presentation necessary to operate the projector and to allow time for writing-down responses.

c. Discussion. The group procedure appeared to offer promise as a method of collecting verbal-learning data. As used here, the results were not directly comparable to those gathered individually. However, there would be no problem in making the procedures comparable. Certainly the advantages of larger samples were important. Four experimenters were used with each group and gathered data on 36 subjects in one session. Working individually, they would have tested only 4 subjects.

In addition, this group method pointed up differences between grades that were not evident from interpolation of data gathered in Experiment III.

Specifically, for both the visual and auditory methods of presentation, the performances of 4th and 7th grade subjects were not reliably different. Therefore, one would have predicted that no difference in performances should occur between the 5th and 6th grades. Inasmuch as the group procedure did reveal significant differences between 5th and 6th grade performances, it appeared that this procedure allowed a more critical analysis of group differences.

Training Projects

A. Introduction and Purpose.

The plan of the study was to devote a portion of the third year to special teaching projects. The underlying goals were to attempt to develop objective methods of measuring the possible success of auditory training and to improve auditory training procedures. The results of the experiments carried out during the first two years were to be used to assist in planning the projects.

The experiments using paired-associate verbal learning with auditory, visual, or combined methods of presentation had revealed no significant differences between Conditions V and C for hard-of-hearing children. Significant differences had been found in the deviations of Condition A from Conditions V and C. Since measures taken with Conditions V and C on paired-associate verbal learning were never different from each other among hearing-loss groups, it appeared that measures taken with these two conditions would not reveal improvements in auditory or auditory-visual reception of communication that might result from special training.

A modified approach to the measurement of the ability of hard-of-hearing children to learn paired-associate lists was explored through a doctoral research project. Four lists of 10 word pairs each were prepared with the intent to control intra-pair relationships. Specifically, the word pairs within each list were constructed as follows:

a. List #1 - Minimal association, neither spelled nor pronounced similarly; e.g., box-sun.

b. List #2 - Visual association, spelled similarly but pronounced differently; e.g., have-cave.

c. List #3 - Auditory association, pronounced similarly but spelled differently; e.g., rough-cuff.

d. List #4 - Visual and auditory association, spelled and pronounced similarly; e.g., boat-coat.

The lists were presented with the Patterson memory drum to groups of children with normal hearing and to groups of children with differing levels of hearing acuity. In comparison with the other lists, all groups required more trials to learn List #1 while the least number of trials were required to learn List #4. For normal-hearing children Lists #2 and #3 were of intermediate difficulty; the pairs that were pronounced similarly required slightly fewer trials. For all hard-of-hearing groups the auditory pairings required more trials than the visual. For the groups with moderately severe to severe hearing losses List #3 required almost as many trials as List #1, and List #2 required about the same number of trials as List #4. The results gave some promise that the lists might differentiate among hearing-loss groups, and also be sensitive to the ability of hard-of-hearing children to use auditory cues. The doctoral study will be reported elsewhere; it is mentioned here because the study grew out of the present project and because the lists were used as part of the pre- and post-testing procedure for the experimental training projects.

The general plan of the training projects was to carry out experimental teaching sessions designed to emphasize the use of auditory stimulation. The teaching was conducted by two members of the research staff who were trained teachers of the deaf and who were also familiar with the purposes of the research. One staff member conducted training sessions throughout the academic year; the other taught two groups daily during the summer session.

Specifically, the plan of the training projects was as follows:

a. To expose groups of hard-of-hearing children to intensive auditory or auditory-visual stimulation.

b. To attempt to find objective measures which would be sensitive to any improvement in performance resulting from the training.

B. Training Projects and Findings.

The experimental training was carried out in four distinct parts. One part consisted of a two-week training program for severely hard-of-hearing children using a pre- and post-testing procedure in order to evaluate the program. Another session was again planned and the procedure repeated. Training projects 1 through 3 were of this type.

A second part was conducted in the Hearing Clinic with hard-of-hearing children who were in attendance in regular classes in school. This work is described in Project 4. The third part, Project 5, was carried out throughout the entire year with pre-school deaf children. Finally, the fourth part, Project 6, was conducted during the summer session. Two groups of children were seen daily for five weeks.

1. Training Project 1. The first project was designed to determine if two weeks of auditory training would result in improved scores of standard tests of auditory discrimination or on paired-associate verbal—learning tasks.

The three children used were 14 to 16 years of age, severely hard-of-hearing, and in attendance at a Day School for the Deaf. Before the training was started, the children were given an extensive battery of tests, including pure tone and speech audiometry, multiple-choice speech discrimination, speech reading with and without amplification, and paired-associate verbal learning. Training consisted of one-half hour of individual auditory training per day for two weeks. At the end of the two-week period, the tests were repeated.

Pre-training tests revealed that none of the children received apparent benefit from amplification. For instance, the scores on the multiple-choice speech discrimination tests did not exceed chance expectancy, and speech reading was not improved with amplification. The results of the tests administered after the training were no different from those administered before the training. Whatever improvement had taken place as a result of the special work could not be measured with the tests administered. Therefore, it was assumed that a more extensive project was indicated.

2. Training Project 2. The second project was planned to give the children greater exposure to auditory stimulation during a two-week period. Again three children, ages 14 to 16 years, with severe hearing losses and from the same Day School were selected and given the pre-training battery of tests. The research-staff teacher took full responsibility for the teaching of the three children for the two-week period. The children were given 3 periods of auditory training each day, and all academic teaching was with a combined auditory-visual approach with as much emphasis on the auditory component as possible. At the end of the period the children were tested again.

The test results obtained before and after training did not differ from each other nor from those obtained in the first training project. Again no objective evidence could be found that the children had benefited from the addition of amplification as measured by the tests used.

In both the first and second projects the focus of attention was to improve the children's ability to recognize words through audition alone when possible and through a combined presentation when the children could not discriminate the words. The approach was as direct as possible in that the children were given repeated presentations of familiar words. When necessary, elemental discriminations were emphasized. For the full-day sessions there were two or three "auditory training" sessions; academic training made optimum use of auditory cues.

As mentioned, no objective evidence was obtained that indicated the children had improved in their ability to profit from the presence of the auditory stimuli. However, the subjective evaluation of the teacher had been that there was an improvement in the day to day performances of the children. At the outset, the subjects payed little or no attention to amplified verbal presentations. The task became one of getting the children "to listen." When forced into "listening" situations all of the children were able to make some simple auditory discriminations. The major finding of the first two projects was that the severely hard-of-hearing children did not readily utilize auditory cues even when concentrated emphasis was placed on auditory stimulation. However, these children could be forced to make auditory discriminations, which they normally did not make.

3. Training Project 3. The third project was an outgrowth of the first two. Four additional children, ages 8 to 12 with severe hearing losses, were trained for half-hour sessions daily for a two-week period. The main purpose of the project was to drill the children on a simple auditory discrimination task and then to test them on the same task in a different environment.

A multiple-choice form of the PB-K lists was chosen as the simplest and most appropriate task. Training was directly focused on learning to distinguish among the multiple-choice items on the lists. Again the children's ability "to listen" improved in the training situation. The pre-training scores were approximately 33% as expected by chance on a list made up of three-choice items. During training the children achieved scores from 60% to 80% correct. The teacher's opinion was that much of the variability from test to test in the same child could be attributed to the effort put into the listening task. At the end of the period the children were brought into the Clinic and administered the tests over the speech testing system. The scores dropped again to chance-expectancy levels.

Two main conclusions emerged from the first three training projects:

a. Severely hard-of-hearing children could be trained to make specific auditory discriminations, which they were not making at the onset of the training.

b. The types of discriminations that were taught did not make a difference between pre- and post-training scores on speech discrimination nor on verbal-learning tasks.

The conclusions drawn here are, of course, limited to the techniques used, the type of children trained, and the test tasks utilized.

4. Training Project 4. Ten hard-of-hearing children, varying in ages from 5 to 11 years, were chosen from children who had been referred to the Hearing Clinic for advice on the use of a wearable hearing aid. Following special testing, the children were assigned to the research teacher for semi-weekly training sessions. The children were seen for periods ranging from six to ten weeks; nearly all of them were wearing their first hearing aids.

The plan of the training program was to emphasize auditory stimulation exclusively. Exercises were set up using gross sounds, rhythms, music, words, and sentences. The gross sounds and music were useful in establishing better listening habits, but the children appeared to show the greatest progress when trained directly on meaningful speech.

At the end of the training sessions, reports were obtained from the parents and from the teachers. Almost without exception they reported that the children had improved in the ability to receive communication during the training program. However, neither the clinical tests nor the verbal-learning tasks gave objective evidence of the improvement. Obviously the reports from the parents and teachers reflected both the benefits derived from the use of the hearing aid and from the training. There was no direct inference to be drawn from the pre- and post-training tests. Further research is necessary to determine whether the subjective evaluations tended to overestimate the improvement or whether the testing techniques employed were not aimed at the proper factors.

5. Training Project 5. One of the more extensive training projects was carried out with five children between 18 and 22 months of age. Careful audiometric testing indicated that they had hearing losses between 70 and 90 db in

the speech range. The children were scheduled for two 45-minute periods of training a week throughout the academic year. None of the children had speech nor responded regularly to auditory stimuli at the start of the training.

The teaching plan was to communicate with each child through audition only. At the outset, the teacher spoke at the child's ear while she worked with the child seated in front of her or on her lap. Later, all children were fitted with earmolds and loaner hearing aids were used. The project director and other members of the staff observed the performances of the children from time to time.

One child was dropped from the program because he had not responded to the training; it was presumed that other problems were present in addition to the hearing loss. Two children showed no progress on the straight auditory presentations after 3 months of training and were switched to a combined auditory-visual approach. Improvement was noted immediately, but the impression was that the response was primarily to the visual component. The remaining two children learned to make good use of auditory communication. It became possible to play the typical training games; such as "Find the ball," or "Give me the doll," using hearing alone. Furthermore, occasaionally a child would bring an object and then "listen" for its name instead of "looking" for it.

The impression of the staff was that these two children had a different orientation to their environment than the two children who were trained with the auditory-visual approach. However, this was an initial impression, and more work must be done before definitive conclusions are drawn.

6. Training Project 6. A final project was carried out during the summer at the Clinic. Two groups of six children each were chosen. One group, which was termed the Deaf Group, was from the Day Schools for the Deaf

and included children with pure tone averages (500-2000 cps) of between 73 and 88 db. These children varied in age from 12 to 16 years and were from Grades 4a to 7b. The other group was hard-of-hearing children from regular classes in public schools. Their pure tone thresholds varied from about 35 to 55 db, and they had PB-50 discrimination scores from 74% to 82%. They ranged in age from 11 to 13 years and were in Grades 5b to 7a.

Training time for both groups was one hour daily for a five week period. Although both groups were selected with six children each, only four in each group completed the program. All children were given extensive preliminary and final tests.

It was clear shortly after the training started that the children in the Deaf Group could not discriminate spoken words through hearing alone. Consequently, the training work was divided into two parts. Spoken language was presented bimodally with as much emphasis on the auditory aspect as possible. Auditory training was confined to discrimination of the elemental aspects of sound. For instance, the children listened and then made judgments of whether music was vocal or instrumental, whether two or three sounds had been present, whether a sound was loud or soft, and whether a sound was high or low. Even these elemental discriminations were difficult for the children. Two of the children learned to judge the difference in frequency between 250 and 500 cps in about 3 days, but the other two could not make the higher or lower judgment until after 3 weeks of practice. All four children had a tendency to confuse pitch and loudness.

None of the test results, including speech reading with and without amplification, showed any improvement after training. However, two parents voluntarily gave instances of increased awareness of sound that they attributed to the training. One set of comments serves to illustrate: The mother reported that her son occasionally now heard and understood a word, that he would respond when called from another room, but that one time when she dropped a pan he came into the kitchen to ask why she had called.

The training with the hard-of-hearing group was almost completely auditory. Part of each day was devoted to listening activities; such as music and sentences of information. A good deal of emphasis was given to vowel and consonant discrimination as described by Kelly (1953). The physiological differences among speech sounds were described to the children.

At the end of the training period all of the test scores were essentially the same as the initial measurements except for the alphabet discriminations. The before and after training scores on the PB-50 lists were 86% and 90%, 82% and 82%, 76% and 80%, 76% and 76% for the four children. On the alphabet discrimination test, the pre- and post-training scores were 75% and 97%, 67% and 100%, 53% and 100%, and 76% and 97%. On one measure, at least, the test results corroborated the instructor's opinion that all the hard-of-hearing children had improved in their ability to make auditory discriminations during the training.

C. Summary.

The conclusions drawn from the training projects were as follows:

a. The children with severe hearing losses made little use of their residual hearing in verbal-learning tasks.

   Short term but intensive training in using auditory cues did not produce measurable improvement in their performances.

b. Children with moderate hearing losses performed proportionately better on the test tasks.

   However, again the training sessions did not result in improved post-test scores.

c. Although the verbal-learning tasks used had given additional insight into the problems of learning in the hard-of-hearing, they did not appear to be more sensitive to changes produced by auditory training than the conventional measures.

The project staff interpreted these findings as indicative of the need for further research on auditory training methods. It appeared that hard-of-hearing children over 10 years of age had firmly fixed patterns of responses to auditory and visual stimuli and did not change these patterns readily. If the observations of the staff teachers that the children were able to make responses to auditory cues that they did not routinely make is accepted as valid, then the children were not functioning up to their capacities. Further research is necessary to determine how training can improve the use they make of their residual hearing.

Summary and Conclusions

There is evidence in the literature that a multisensory presentation of material for verbal learning is superior to a presentation through only one modality. Specifically, a combined auditory-visual presentation is considered superior to a presentation that is either auditory or visual alone. However, the effect of bisensory presentation is likely to be different when one sensory modality is deficient. Although educators of the hard-of-hearing and deaf have reported improvement in the reception of communication, in the development of speech, and in the growth of academic achievement when amplified auditory stimulation is part of the teaching program, there is little evidence in the literature of careful validation of such statements.

One attempt to carry out an experimental study of bisensory versus unisensory presentation in hard-of-hearing and deaf children was made in 1952. The purpose of the study was to compare performances on a verbal-learning task presented visually to performances on the same task presented visually and auditorily. On the task studied the bimodal presentation was not superior to the visual presentation.

The present project was proposed as a study of one type of verbal learning in children. The primary purpose was to investigate the relationships between performance on the task and the method of presenting the task. The learning task was paired-associate word lists, in which the subject learned to anticipate the response member of the pair before it was revealed to him. The methods of presenting the paired-associate lists were auditory (A), visual (V), and combined auditory-visual (C). Sub-conditions were used in which groups of subjects learned two lists, the first presented by A, V, or C and the second presented by A, V, or C. The subjects were normal and hard-of-hearing children in several age-grade groups.

Answers were sought to the following types of questions:

a. Is the sensory presentation method a variable that affects the rate of learning?

b. Are there differences in retention ability related to the method in which the material was originally presented for learning?

c. What are the effects of learning with one method of presentation upon subsequent learning with the same or another method of presentation?

d. In what ways are the performances of hearing-handicapped children different from the performances of normal-hearing children?

e. What are the relationships between the method of stimulus presentation and the age or ability of the subjects?

A final objective of the projects was to determine the usefulness of paired-associate verbal-learning tasks as measures of the efficiency of techniques of auditory training with hard-of-hearing children. Special training projects were carried out with hearing-handicapped children.

A. Procedures

A total of nineteen lists of paired-associate words were used in the project. Eighteen of the lists were constructed using three to five letter monosyllabic words not above the fourth grade reading vocabulary. The remaining list was made up of four-letter nonsense syllables. The number of word pairs used in a list varied from four to ten. Nine of the lists were standardized for equivalence of performance when presented either through audition or vision to fourth grade children. The purpose of the standardization procedure was to prepare for repeated measurements when necessary.

Three basic pieces of apparatus were used to present the lists of word pairs to the subjects. A Patterson memory drum was used for the visual condition. An Ampex, Model 601, tape recorder with a headset was used for the auditory presentation. An Ampex, Model 601-2, tape recorder and an original electronic memory drum were used for the combined condition. The electronic drum was controlled by tone signals recorded on one half of the magnetic tape; the paired-associate words were recorded on the other half. With this apparatus the visual and the auditory components of the combined method of presentation were always synchronous. In one study a group learning situation was utilized; the lists were presented visually with a Bell and Howell slide projector and auditorily with the Ampex tape recorder and a speaker.

The subjects in the study were children from the schools in the Detroit Metropolitan Area. Normal-hearing subjects were selected from the second, third, fourth, fifth, sixth, seventh, and tenth grades. Hard-of-hearing subjects in the same grade range were selected from the special programs for the hard-of-hearing and deaf. Children in the experimental teaching program ranged in age from two to sixteen years. All subjects were naive with regard to the verbal-learning task.

All subjects were tested individually except for the one group experiment. Learning of the paired-associate lists was by the anticipation method. Three general measures of learning were used: 1) number of trials to a criterion, 2) number of correct responses over a given number of trials, and 3) retention scores. Throughout the study a trial was defined as one presentation of each word pair on the list. Record was kept of all responses, correct and incorrect.

B. Results

A total of approximately 2500 subjects were used in the standardization procedures and in the eight experiments conducted for the project. Each of the eight experiments is summarized briefly in the following subsections.

1. Experiment I consisted of nine sub-conditions, in which a subject learned a four-pair list by one of three methods of presentation (A, V, or C) and an eight-pair list by one of three methods of presentation (A, V, or C). A

total of 270 fourth grade children were selected and assigned at random, 30 each, to the nine sub-conditions. Retention scores were obtained on each subject one week after his learning session. The findings of the experiment were as follows:

a. The ninety subjects who learned the four-pair list visually required fewer trials to complete the task than did the subjects who learned the list with either the auditory or combined presentation.

b. There was no significant difference between the mean number of trials required to learn the eight-pair list when presented visually or auditorily; this finding was expected since the list had been standardized using these two conditions.

c. The performance with the combined method of presentation was not superior to either the auditory or the visual methods alone.

d. There was some evidence that charging the method of presentation between the four- and eight-pair list resulted in a poorer performance when learning the eight-pair list, but the evidence is considered inconclusive until further research is done.

e. Retention scores were generally equivalent among the nine sub-conditions of the experiment; if anything, retention scores were best when the material to be learned had been presented auditorily.

2. Experiment II was designed to determine if marked differences in centile rating on Raven's Progressive Matrices were related to differences in performances on the verbal-learning task. Fourth grade children were selected who had scored in the 0-15 and 85-100 centile range on the Progressive Matrices. Five Sub-conditions, A - A, V - A, V - V, A - V, and C - C, were used. In this experiment ten trials were given for the first list; the second list was learned to the criterion of one perfect trial. The first letter designated the method of sensory presentation on the first list, and the second letter designated the presentation method for the second list. Analyses were carried out on the scores obtained from the second list only. Eight children served

as subjects for each sub-condition in both centile groupings. The results of the experiment were as follows:

a. When the means for the sub-conditions were pooled, there was no difference in the numbers of trials required to learn the eight-pair list for the two centile groups.

b. Within the high centile group there were no significant differences among the sub-conditions.

c. Within the low centile group there were signficant differences among the sub-conditions; the subjects assigned to C - C and A - A performed best while the subjects assigned to V - V and A - V performed poorest.

d. The subjects in the high-centile group had better retention scores than the subjects in the low centile group when the scores were pooled for the sub-conditions.

3. Experiment III was designed to extend the study of paired-associate verbal learning to grades lower and higher than the fourth grade. The five sub-conditions described under Experiment II were used. Seventy-five children from each of the second, third, seventh, and tenth grades served as subjects. The main findings of the experiment were as follows:

a. When sub-conditions were pooled, the performance improved from grade to grade from the second to the tenth, although most adjacent grades were not significantly different from each other.

b. In all grades the subjects required fewer trials to learn the second list under Sub-condition A - A; the change in method of sensory presentation between the two lists was associated with poorer performances.

c. There were no significant differences in the performances for Sub-conditions V - V and A - V.

d. When both learning tasks were A, V, or C and the scores were pooled by grades, there were no significant differences among the methods of presentation.

The grade by condition interaction term was significant; grades two and three performed poorest on the visual presentation while the highest grades tended to perform about equally well on the conditions.

e. Subjects learning with the combined presentation did not show superior performances.

f. Retention scores were not significantly different among the conditions nor among the grades.

4. In Experiment IV the subjects were hard-of-hearing children with varying levels of hearing acuity. Five hearing-level groups were used: 16-30 db, 31-45 db, 46-60 db, 61-75 db, and 76-90 db. Because the number of children available to use as subjects was limited, each one learned three eight-pair lists to the criterion of one perfect trial, one each by A, V, and C. The order of learning the lists used and the order of utilizing the sensory presentation methods was counter-balanced. The results of the experiment were as follows:

a. With the combined and visual methods of presentation the hard-of-hearing subjects performed almost as well as the normal fourth-grade children.

b. The performances, when the lists were presented auditorily, were poorer than had been expected--subjects in the two most severe hearing-loss groups were unable to learn the list, and the subjects in all groups required the greatest number of trials to learn the lists under this condition.

c. There was no evidence that the performances of the hard-of-hearing subjects were better with the combined condition than with the visual condition.

5. The first four experiments revealed essentially equivalent performances under Conditions A, V and C for the normal-hearing subjects and for Conditions V and C for the hard-of-hearing subjects. A possible factor in the three findings might have been the careful standardization on Conditions A and V carried out with fourth grade children. In Experiment V new lists were prepared on the basis of grammatical usage without regard to possible effects on auditory or visual presentations. Two lists were prepared from common words with single (S) grammatical usage, nouns; and two lists were prepared from common words with double (D) grammatical usage, nouns and verbs. The four lists of words were arranged into stimulus and response positions in paired-associate lists as follows: D - S, S - S, S - D, and D - D. The lists were presented to 120 fifth and sixth grade subjects through Conditions A, V, and C.

The results of the experiment were as follows:

a. When list effects were pooled, there were no differences among the A, V, and C methods of presentation.

b. Although the differences did not reach a satisfactory level of statistical significance, the single usage words were consistently easier to learn than were the double usage words.

c. Performances under the three methods of presentation appeared to be more closely associated with variation in the response words than in the stimulus words.

6. Experiment VI was one of three pilot studies designed to explore specific aspects of verbal learning in children. In this experiment three samples of tenth grade children, 10 per sample, were presented a paired-associate list of nonsense syllables. Each group had six preliminary trials and six test trials. On the preliminary trials one group watched for four trials and pronounced the syllables as presented for two trials, a second group watched for two trials and pronounced for four trials and the third group pronounced the syllables on all six trials. The group which pronounced for four trials made the most correct responses on the six learning trials; those who pronounced for only two trials made the fewest correct responses. The results suggest that the pronounciation of the material may be a significant variable in the number of trials required to learn a list. The effect of this variable in deaf children who do not hear their pronounciations needs to be studied.

7. Experiment VII represented another attempt to search for differences in performances on a verbal-learning task that might be associated with an auditory or visual method of presenting the lists. In the study the word pairings were changed in the middle of a task. It was assumed that the effect of the change would be different with the two methods of presentation. A group of 20 tenth grade children were assigned to the A and V Conditions, 10 per condition. The subjects were presented a list of word-pairs for six trials and instructed to learn the pairs. For the next six trials they were then presented a new

form of the list in which the response members of the first list were shifted so as to form new pairings. The data revealed that the subjects learning the original list visually gave significantly more correct responses than subjects learning the list auditorily. However, on the second list in which the stimulus and response words had been re-paired, the visual group gave fewer correct responses than the auditory group. An analysis performed on the difference scores between the first and second blocks of trials for the two groups revealed a significant difference between Conditions A and V. Although these differences suggest that learning the original list under Condition V developed stronger associations for the word-pairs, this measure is contaminated by the fact that subjects in Condition V experienced a greater number of reinforced responses on the original learning task.

8. Over two years of conducting verbal-learning studies in the schools had revealed several problems inherent in administering the tasks individually. Experiment VIII was designed to attempt to present one of the standard paired-associate lists in a group situation. A slide projector and a tape recorder with a speaker were used for Conditions V and A. Two groups of children from the fifth grade and two groups from the sixth grade served as subjects. Groups varied in size from 34 to 36 subjects. The results of the experiment were as follows:

a. The absolute performance levels were better in the group situation, probably due to the increased intra-pair time allowed for writing down responses.

b. The relative performances were no different from those found in the individual measurements; i.e., there were no significant differences between Conditions A and V for either grade.

c. The sixth-grade subjects performed significantly better than the fifth grade subjects on both Conditions A and V.

It was interesting that the group procedure revealed significant differences between the fifth and sixth grades when the smaller sample studies in which the tasks were administered individually had not shown differences between the fourth and seventh grades.

C. Training Projects

A series of special auditory-training projects were conducted during the third year of the study by two members of the research staff who were trained teachers of the deaf. The purposes of the projects were to determine if concentrated auditory-training sessions would improve the performances of hard-of-hearing children on tasks of auditory discrimination and on tasks of verbal learning. Small groups of children were used, but wide differences in age and hearing ability were included.

The results of the studies did not generally reveal the expected changes in performances. In only one group was objective evidence found of improvement in performance. Further special work is necessary to accomplish the goals that motivated the work. However, two findings of importance emerged: 1) The teachers discovered that all children could make auditory discriminations in a forced-choice situation that they could not and did not regularly make. 2) Training of very young children gave some evidence that the auditory orientation of the children could be improved by emphasis on auditory stimulation and de-emphasis of visual stimulation.

D. Conclusion

The study has made several basic contributions to the psychology of learning particularly as it applies to children. The main contributions may be summarized as follows:

a. A new electronic memory drum was developed that permits greater flexibility in the presentation of rote learning material than has been available in the past.

b. Rote paired-associate learning was shown to be a practical procedure for studying one aspect of learning in children.

c. Data were gathered on the learning of meaningful paired-associate lists in large numbers of children of school age.

d. Comparisons were made among rote learning conditions wherein the methods of sensory presentations were varied.

e. Comparisons were made among the performances of normal-hearing and hard-of-hearing children.

The project represented an initial attack upon the problem of understanding how children use audition and vision in learning verbal material and how hearing loss affects the process.

REFERENCES

1. Bartlett, M. S. Some examples of statistical methods of research in agriculture and applied biology. *J. R. statist. Soc. Suppl.,* 1937, 4, 137-170.

2. Bugelski, B. R. The role of familiarity in the transfer of training situation. Paper read at Amer. Psychol. Assoc., New York, Sept., 1957.

3. Cieutat, V. J., Stockwell, F. E., & Noble, C. E. The interaction of ability and amount of practice with stimulus and response meaningfulness (*m*, *m'*) in paired-associate learning. *J. exp. Psychol.*, 1958, 56, 193-202.

4. Duncan, D. B. Multiple range and multiple F tests. *Biometrics*, 1955, 11, 1-42.

5. Elliott, F. R. Memory for visual, auditory, and visual-auditory material. *Arch. Psychol*., 1936, No. 199, 29, 1-59.

6. Fuller, C. W. A study of the growth and organization of certain mental abilities in young deaf children. Unpublished doctoral dissertation, Northwestern University, 1959.

7. Gates, A. I. *Gates' word list for primary grades*. Teachers College, Columbia University, 1932.

8. Glaze, J. A. The association value of nonsense syllables. *J. genet. Psychol*., 1928, 35, 255-267.

9. Graunke, W. L. Effect of visual-auditory presentation on memorization by children with hearing impairment. Unpublished doctoral dissertation, Northwestern University, 1959.

10. Hudgins, C. V., Silverman, S. R., & Harrison, C. E. *Summary Report of the Group Hearing Aid Project*. National Research Council, October 1957.

11. Hull, C. L. The meaningfulness of 320 selected nonsense syllables. *Amer. J. Psychol*., 1933, 45, 730-734.

12. Hunt, R. G. Meaningfulness and articulation of stimulus and response in paired-associate learning and stimulus recall. *J. exp. Psychol*., 1959, 57, 262-267.

13. Johnson, E. H. The ability of pupils in a school for the deaf to understand various methods of communication. *Amer. Ann. Deaf*, 1948, 43, 194-314.

14. Kay, B. R. Intra-individual differences in sensory channel preferences. *J. appl. Psychol*., 1958, 42, 166-167.

15. Kelly, J. C. *Clinician's handbook for auditory training*. Dubuque, Iowa: Wm. C. Brown, Co., 1953.

16. Kimble, G. A., & Dufort, R. H. Meaningfulness and isolation as factors in verbal learning. *J. exp. Psychol*., 1955, 50, 361-368.

17. Lindquist, E. F. *Design and analysis of experiments in psychology and education*. Boston: Houghton Mifflin, 1953.

18. Mann, H. B., & Whitney, D. R. On a test of whether one of two random variables is stochastically larger than the other. *Ann. Math. Statist*., 1947, 18, 50-60.

19. Noble, C. E. An analysis of meaning. *Psychol. Rev*., 1952, 59, 421-430.

20. Noble, C. E. & McNeely, D. The role of meaningfulness (m) in paired-associate verbal learning. *J. exp. Psychol.*, 1957, 53, 16-22.

21. Oleron, P. A study of the intelligence of the deaf. *Amer. Ann. Deaf*., 1950, 95, 179-195.

22. Raven, J. C. *Progressive matrices, Book Form, Sets A, B, C, D, and E.* London: Lewis and Co., Ltd., 1938.

23. Sheffield, F. D. The role of meaningfulness of stimulus and response in verbal learning. Unpublished doctoral dissertation, Yale University, 1946.

24. Siegel, S. *Nonparametric statistics*. New York: McGraw-Hill, 1956.

25. Spache, G. *Spache binocular reading test*. Meadville, Pa: Keystone View Co., 1943.

26. Thorndike, E. L. *Teachers word book of 20,000 words*. Teachers College, Columbia University, 1932.

27. Thorndike, E. L., & Lorge, I. *Teachers word book of 30,000 words*. Teachers College, Columbia University, 1944.

28. Underwood, B. J. *Experimental psychology*. New York: Appleton-Century-Crofts, 1949.

29. Wedenberg, E. Auditory training of severely hard of hearing preschool children. *Acta oto-laryngol*., Supplement 110, 1954, 31-34.

APPENDIX A

Standardization

The standardization procedure was designed to provide lists that were of equivalent difficulty when presented either auditorily or visually. Monosyllabic nouns of three to five letters each were chosen from the first four Scott-Foresman and Ginn Readers, as well as Thorndike (1932), and Gates (1935) word lists. Words were then drawn at random from this word source to make up a total of nine 10 word-pair lists and four 5 word-pair lists. Word pairs which were likely to create obvious associations were omitted.

The first attempt at standardization consisted of presenting each of the 10 word-pair lists to fourth grade children. Ninety subjects were drawn from the total fourth grade population who had passed the hearing and vision tests and whose academic achievement was considered normal. Ten subjects were randomly assigned to each of the nine lists, five to receive visual presentation and the remaining five to receive auditory presentation.

The subject was presented a 5 word-pair list and instructed to learn the word pairs. Following this, the subject was presented the appropriate 10 word-pair list. Learning was by the anticipation method for both lists. The subject continued until reaching a criterion of one trial on which he correctly anticipated each of the response words, or if he failed to meet this criterion, the task was continued for 30 trials. Table A.1 presents the means for the A and V Conditions for the 10-pair lists. Each mean is based upon the scores of 5 subjects.

TABLE A.1-Mean trials for the nine 10 word-pair lists under Conditions A and V.

Lists	Conditions	
	Auditory	Visual
1	15.0	17.4
2	14.6	16.8
3	23.2	17.0
4	13.6	17.0
5	13.2	23.0
6	11.8	24.2
7	19.6	22.6
8	16.6	20.0
9	10.8	20.0

Since it was desired that the lists be learned in 10 to 12 trials and since certain word pairs were consistently more difficult to learn with one method of presentation than with the other method, the lists were reduced to 8 word-pairs by removing the deviant pairs. The 5 word-pair lists were also reduced to 4 word-pair lists. The revised lists were presented to another group of 90 subjects following the same procedure as described above. Table A.2 presents the means for each of the nine 8-pair lists following presentation of 4 word-pair List #1.

TABLE A.2-Mean trials for the nine 8 word-pair lists under Conditions A and V.

Lists	Conditions	
	Auditory	Visual
1	12.8	18.8
2	15.4	14.0
3	25.2	16.8
4	12.0	14.2
5	13.4	13.2
6	11.4	13.8
7	13.2	18.8
8	19.8	17.8
9	15.0	17.8

Inasmuch as the lists were still not adquately standardized, further revisions were made of Lists #1, #3, #7, #8, and #9. Fifty additional subjects were tested, 5 subjects per list per condition, in order to evaluate the influence of the revisions. Table A.3 shows the means for Conditions A and V on the nine 8 word-pair lists following presentation of 4 word-pair List #1. The results indicated that the lists were of relatively comparable difficulty regardless of method of presentation.

TABLE A.3-Mean trials for the nine 8 word-pair lists under Conditions A and V.

Lists	Conditions		Total Mean
	Auditory	Visual	
1	10.2	13.0	11.6
2	15.4	14.0	14.7
3	10.0	12.6	11.3
4	12.0	14.2	13.1
5	13.4	13.2	13.3
6	11.4	13.8	12.6
7	13.0	12.2	12.6
8	9.2	12.0	10.6
9	14.2	14.0	14.1

Finally, an additional 180 subjects were tested on the nine 8 word-pair lists. Prior to receiving the 8 word-pair lists, 90 of the subjects were presented 4 word-pair List #2 and 90 subjects were presented 4 word-pair List #3. Half of the subjects in each of these two groups were presented the 4 word-pair list visually and half were presented the list auditorily. Following this, the 90 subjects who had received List #2 were assigned to each of the nine 8 word-pair lists, 10 subjects per list. Within any group of 10 subjects, 5 received Condition A, as they had on the 4 word-pair list, and 5 received Condition V. The subjects who received 4 word-pair List #3 followed the same procedure.

Table A.6 presents the means and standard deviations for each of the nine lists. Each mean is based upon 15 subjects, 5 from each of the three 4 word-pair list groups.

TABLE A.6-Mean trials for the nine 8 word-pair lists under Conditions A and V following presentation of the three 4 word-pair lists.

Lists	Conditions				Total Mean
	Auditory	S.D	Visual	S.D.	
1	10.0	4.5	14.0	5.1	12.0
2	13.0	5.7	12.0	4.3	12.5
3	12.9	5.2	12.0	4.1	12.5
4	11.0	4.3	13.0	4.8	12.0
5	13.6	5.3	14.0	4.6	13.8
6	11.2	3.7	14.4	6.4	12.8
7	12.8	7.8	10.6	5.1	11.7
8	13.2	6.5	14.4	7.1	13.8
9	12.2	5.1	14.3	5.1	13.2

APPENDIX B

Paired-associate lists prepared for the project

I. Four word-pair lists used in Experiments I and IV.

1. BUS-PIG
DAY-BARN
ROPE-MUD
BIRD-ROSE

2. CROW-DREAM
WOLF-SOUP
TOP-WORD
QUEEN-POND

3. CARD-DUCK
DISH-WIND
KNEE-FROG
POT-SHELL

II. Eight word-pair lists used in Experiments I, II, III, IV, and VIII.

1. BAG-SAND
FLAG-SOAP
CART-HAIR
TEAM-LAMB
BOAT-PORCH
GIFT-DRUM
FACE-BEAN
COAT-KNIFE

2. FISH-HAY
DOG-HORN
MOOSE-BAND
JOKE-GUN
BRIDE-TOE
MOUTH-YARD
PATH-SONG
SALT-GATE

3. TAG-ARM
DOLL-LAKE
EGG-TENT
RUG-GOOSE
BLOCK-HOME
HAT-DOOR
KEY-RAT
MOUTH-BOOK

4. LOG-PEARL
BOY-SHORE
OWL-BREAD
DESK-TOWN
HEART-BALL
VOICE-COW
CHILD-HILL
HORSE-ROOM

5. MAN-CLOUD
JAW-WORM
PIT-BOOT
ROCK-PIE
FIRE-GLUE
FORT-SKY
NIGHT-STRAW
HAND-FENCE

6. FOOT-CAGE
LUNCH-DUST
JAR-BRICK
CAB-NOSE
SNOW-BOX
TRAIN-WAR
SHIRT-CAT
BELL-GRASS

APPENDIX B

7. SNAKE-ICE
MAP-GIRL
SHIP-NEST
TIME-MOON
HEN-CAP
STAR-LEG
PRIDE-STORE
MILK-FARM

8. WHIP-PEN
HEAD-STOVE
LAWN-CAKE
NET-FOX
HEEL-CAR
BIKE-GOAT
SMOKE-BED
BONE-CLOCK

9. COAL-TREE
TOY-AIR
FOOD-WALL
CHIEF-SLED
BUSH-KING
RAIN-WIFE
WHEEL-MOUSE
ROAD-SHOE

III. Ten word-pair lists used in Experiment V.

D-D SIGN-BACK
SHOP-WAVE
HAND-ROSE
CLUB-SOIL
FISH-SLIP
RANG-LAND
ROLL-PICK
IRON-SHOW
ROCK-MILK
FACE-SHIP

D-S LAND-BELL
SHIP-CARD
SIGN-ROPE
ROSE-DOOR
FACE-SALT
ROLL-SEED
HAND-DESK
BACK-BIRD
SHOP-NECK
WAVE-COAL

S-S TREE-MOON
BOOK-SALT
DOOR-SONG
GIRL-CARD
WALL-KNEE
HILL-LION
SNOW-DESK
BIRD-ROPE
BOAT-ROOF
COAL-LAKE

S-D BELL-FACE
DOOR-ROCK
CARD-IRON
SEED-RING
DESK-ROLL
ROPE-FISH
SALT-SHOW
NECK-SHOP
BIRD-HAND
COAL-SIGN

APPENDIX B

IV. Ten nonsense syllable-pairs used in Experiment VI.

MRID-JELP

GORT-KEST

STIN-HOUV

BLIF-FRAN

FREP-HUNZ

DAFE-LONK

SOOL-FLIT

VARP-CRIL

FLAN-HAKE

SEFS-QUOF

V. Five word-pair lists used in Experiment VII.

First pairing:	Second pairing:
CLUB-SOIL	CLUB-WAVE
HAND-ROSE	HAND-ROSE
FISH-SLIP	FISH-SOIL
SIGN-BACK	SIGN-SLIP
SHOP-WAVE	SHOP-BACK

APPENDIX C

Summary of intercorrelations among 5 variables for each of the nine sub-conditions in Experiment I.

The variables were as follows:

X = Scores on 8 word-pair list.
Y = Scores on 4 word-pair list.
Z = Centile scores on Raven's Progressive Matrices.
RA = Reading achievement scores.
R = Retention scores.

A-A

	Y	Z	RA	R
X	.32	-.26	.21	.16
Y	X	-.04	.08	-.12
Z	X	X	.13	-.26
RA	X	X	X	.62**

V-V

	Y	Z	RA	R
X	.14	-.11	-.51**	.13
Y	X	.43*	-.26	.01
Z	X	X	.32	-.12
RA	X	X	X	.06

V-A

	Y	Z	RA	R
X	.30	-.02	-.02	.06
Y	X	-.12	-.04	.34
Z	X	X	.17	.06
RA	X	X	X	.42

A-V

	Y	Z	RA	R
X	.03	.01	-.22	.21
Y	X	-.11	-.26	-.15
Z	X	X	.11	.25
RA	X	X	X	.02

C-A

	Y	Z	RA	R
X	.55**	-.24	-.26	-.24
Y	X	-.02	-.16	-.21
Z	X	X	.12	.08
RA	X	X	X	-.12

C-V

	Y	Z	RA	R
X	.32	-.18	-.02	.18
Y	X	.22	.20	.31
Z	X	X	.46	.20
RA	X	X	X	.42**

APPENDIX C

C-C

	Y	Z	RA	R
X	.21	-.10	-.01	.11
Y	X	-.03	-.13	-.31
Z	X	X	.01	*.46
RA	X	X	X	.10

Y-C

	Y	Z	RA	R
X	.09	.08	-.11	.01
Y	X	-.34	-.05	-.36
Z	X	X	.49	.22
RA	X	X	X	.02

A-C

	Y	Z	RA	R
X	.30	-.18	-.01	.13
Y	X	-.05	-.14	.24
Z	X	X	**.60	.04
RA	X	X	X	.22

*r Sig. P = .05
**r Sig. P = .01

15 3193 ③